A neurophysiological and behavioural assessment of interventions targeting attention bias and self-control in binge drinking

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2016

Thesis submitted in partial fulfilment of the requirements for the degree of
Master of Arts in Psychology

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Abstract

Attention bias modification (ABM) can decrease the selective visual attention paid to alcohol-related cues shown by a variety of drinkers, but is hindered by its inability to decrease craving. To address this shortcoming, an intervention to decrease alcohol craving by increasing sense of control was proposed as a complement to ABM. The current study aimed to investigate the effects of two such brief interventions administered singly or in combination, with the hypothesis that the combination would be more effective than either intervention alone. ABM involved a visual dot-probe task and sense of control training applied the intervention elements of choice, goal setting, information enhancement and reinforcement to simple cognitive tasks. Participants were a sample of 41 binge drinkers, recruited as an at-risk drinking group, and 10 non-binge drinkers. Binge drinkers were defined using a binge score, measuring drinking speed, number of times being drunk in the past 6 months, and percentage of times getting drunk while drinking. The binge drinkers received either ABM, sense of control training, both interventions, or no intervention, and were compared with non-binge drinkers who received no intervention. Groups were assessed on primary dependent variables of change in alcohol attention bias (measured in a visual dot-probe task, behaviourally and neurophysiologically with cue-elicited ERPs), change in alcohol craving, and alcohol consumption. Binge drinkers showed a non-significant trend for higher alcohol attention bias scores than non-binge drinkers. ABM had no effect on binge drinkers' behavioural or electrophysiological markers of alcohol attention bias. Sense of control training did not increase personal sense of control, failing to replicate previous reports, but showed some evidence of a protective effect against decreased task accuracy and against increased alcohol craving. Binge drinkers receiving the combined intervention consumed less alcohol in a bogus taste test than participants who received no intervention. Conclusions about the suitability of ABM for binge drinkers should be reserved for future investigations using binge drinking samples showing baseline attention bias, perhaps older participants with a longer history of binge drinking, but there is some support for the use of a combined intervention to decrease alcohol consumption. The findings also suggest the need for more diverse accounts of binge drinking that carefully consider the extent and duration of the drinking pattern.

Acknowledgements

I would like to express my appreciation to my supervisors for their guidance in this project: to Prof. Richard Jones for his precision and practical experience and advice, and to Dr. Juan Canales for his considered and constructive feedback, even at great distance. Thanks are also due to Paul Russell for his review of the study proposal, and to Jon Wiltshire for his programming assistance.

I am thankful for my time at the New Zealand Brain Research Institute, and the stimulation it provided. I am also grateful to Reza Shoorangiz for his generous instruction in EEG processing and assistance with script writing.

Finally, I would like to thank my parents for their warm support in this and all things.

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Glossary of Terms

ABM:	Attention Bias Modification
AUDIT:	Alcohol Use Disorders Inventory Test
BD:	Binge drinker
BS:	Binge score
C:	Control (non-binge drinkers)
CIC:	Concept Identification Cards (task used in control intervention)
PACS:	Penn Alcohol Craving Scale
SCI:	Shapiro Control Inventory
Summary-SCI:	Summary sense of control measure
TLC:	Time-locked craving
TSSCI:	Task-specific control measure

Drinking groups: Binge drinkers and non-binge drinkers

Experimental groups: Groups experiencing control and attention interventions at different levels

Experimental group	*n*	Drinking group	Sense of Control Intervention	Attention Intervention	
1	10	BD	Training	Training	Combined intervention
2	10	BD	No training	Training	Attention training only
3	10	BD	Training	No training	Sense of control training only
4	11	BD	No training	No training	Untrained binge drinkers
5	10	C	No training	No training	Untrained non-binge drinkers

1. INTRODUCTION

Despite a reduction in alcohol consumption rates in the last decade, many New Zealanders exhibit hazardous drinking patterns which are associated with risk of harm to the drinker and those around them (Ministry of Health, 2013b). Of particular recent interest is a binge drinking pattern, which involves frequent high-volume alcohol consumption in short time periods (Herring, Berridge, & Thom, 2008). This pattern accounts for around a quarter of drinking adults (McMillen, Kalafatelis, & de Bonnaire, 2004), and while it may be seen as normative given local acceptance of drunkenness and the number of drinkers drinking to the point of loss of control (McMillen et al., 2004), recurrent binge drinking is one of the drinking patterns that adds the most damage to the level of alcohol consumption (Babor et al., 2010). There is risk of acute harm as well as functional deficits that mirror impairments seen in dependent drinkers, which electrophysiological measures such as electroencephalogram (EEG) recording and brain imaging can sensitively measure and even detect before they are expressed at the behavioural level (Petit, Maurage, Kornreich, Verbanck, & Campanella, 2014).

An impairment particularly relevant to the maintenance of a binge drinking pattern and a potential escalation to habitual or compulsive alcohol use is *attention bias* for alcohol. The incentive-sensitisation theory of addiction holds that sensitised neural systems from repeated drug use mediate the attribution of greater salience to the drug and drug-related cues (stimuli such as a picture of a beer bottle, or the smell of liquor; Robinson & Berridge, 1993). In this process and through associative learning drug cues take on a heightened importance or salience which can manifest as an attention bias, in which these cues attract attention at the expense of other stimuli. Attention bias is both a product of, and a contributing factor to, excessive use, and is associated with craving (Field, Munafò, & Franken, 2009), which makes it a promising intervention target for preventing relapse in dependent drinkers and for disrupting the processes that lead to compulsive use in at-risk groups.

Alcohol, the most used recreational drug in New Zealand (Ministry of Health, 2009), also produces an attention bias with use, an effect found in social through to dependent drinkers (Field & Cox, 2008). Attention bias can be manipulated through Attention Bias Modification (ABM), which retrains attention typically using visuospatial cueing paradigms (MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002). There is a substantial literature on the use of ABM to retrain the attention bias towards threatening stimuli seen in

emotional disorders such as anxiety and depression, but fewer studies have investigated retraining attention bias towards appetitive stimuli. The best available review suggests a small effect of ABM in retraining attention bias for appetitive stimuli, but acknowledges that more studies need to be undertaken (Beard, Sawyer, & Hofmann, 2012). In the few studies that do exist concerning alcohol, ABM has reduced attention bias in participants with a range of drinking patterns (e.g., Field et al., 2007; Field & Eastwood, 2005; Schoenmakers et al., 2010; Schoenmakers, Wiers, Jones, Bruce, & Jansen, 2007; Townshend & Duka, 2001). Binge drinkers specifically have not been trained with ABM, although they too exhibit baseline attention bias for alcohol when measured with event-related potentials (ERPs) in visual oddball paradigms (Petit et al., 2012).

One major shortcoming of ABM is that there is little consistent evidence that it has an impact on subjective experiences such as craving, which plays a vital part in excessive drug use. Interventions to increase sense of control could complement attention retraining well, as they have been shown, in the case of social and moderate drinkers, to reduce craving as well as alcohol attention bias (Shamloo, 2007, as cited in Fadardi, Shamloo, & Cox, 2011; Shamloo & Cox, 2014). Increasing sense of control can be achieved through problem-solving-type tasks delivered with additional instructions that emphasise the participant as effective in producing a result or making a change, and that encourage a view of the environment as receptive and responsive to those efforts. The sense of control interventions have also been shown to improve task performance, in terms of speed and accuracy, which might extend to a subsequent task or task-based intervention and make it more effective. If results from these two studies can be replicated, then a control intervention and an attention intervention could complement each other and be more effective than either alone in reducing craving, reducing attention bias for alcohol and, as a result, reducing the amount of alcohol consumed after training. The present study aimed to investigate this question with a sample of binge drinkers as an at-risk group.

After introducing the topic of alcohol- and binge-drinking-related harm, the remainder of this chapter critically reviews the literature on the relationships between alcohol and attention bias and between alcohol and sense of control, and considers the ways in which interventions designed to manipulate alcohol attention bias and sense of control might be used to improve drinkers' health outcomes. The review concludes by making an argument for testing a combined intervention and the utility of using a binge drinking sample, before presenting the hypotheses suggested by this review and examined in this thesis.

1.1. Alcohol

1.1.1. Alcohol in Aotearoa New Zealand

Alcohol is widely consumed in New Zealand, with 80% of adults reporting past-year consumption and a third drinking alcohol regularly (Ministry of Health, 2013b). Since 2006/2007, all age groups have seen a decrease in consumption and in rates of hazardous drinking patterns while there has been an increase in low frequency drinkers; however, fewer adults are moderating their drinking, and one in five New Zealanders, equating to about 532,000 people, has a hazardous drinking pattern. Measures of risk of alcohol-related harm, including those used by New Zealand's Ministry of Health, typically use the Alcohol Use Disorders Inventory Test (AUDIT; Saunders, Aasland, Babor, De La Fuente, & Grant, 1993), which categorises harmful and hazardous drinking using cut-off scores. *Harmful* use results in consequences to physical or mental health, and possibly negative social effects. *Hazardous* use is drinking that poses risk of negative consequences to the drinker or others, and is of public health significance even in the absence of a current disorder in the drinker. Rates of hazardous drinking are especially high among young people aged 18 to 24, and among Māori and Pacific adults and those living in deprived areas. The New Zealand picture of slowing consumption rates overall but less moderate and more heavy drinking tracks trends seen elsewhere, such as in the United Kingdom where since 2000 there has been an increase and plateau in the number of heavy drinkers as well as an increase in abstainers and light drinkers, leading some to suggest a polarisation of drinking (Measham, 2008).

1.1.2. Binge drinking pattern

Along with average volume of consumption, it is important to consider the pattern of drinking, as these factors both determine the types of short- and long-term consequences (Babor et al., 2010). Babor et al. (2010) described recurrent binge drinking and drinking to intoxication as the drinking patterns that add the most damage in terms of population social and health burden, and taking the prevalence of binge drinking into account—in the United States, for example, binge drinking is the most common hazardous drinking pattern (Center for Disease Control, 2014), and in New Zealand binge drinkers make up 22% of adults and 27% of drinking adults (McMillen et al., 2004)—binge drinking has perhaps appropriately been subject to much academic and policy-focused attention. The term originally described a bout of heavy substance use over several days during which other responsibilities and activities are neglected (Tomsovic, 1974), but is now commonly used to refer to high volume

single occasion drinking (Wechsler, Davenport, Dowdall, Moeykens, & Castillo, 1994; Wechsler, Dowdall, Davenport, & Rimm, 1995). However, the literature is plagued by inconsistent definitions of what binge drinking is (Dawson, 2011; Herring et al., 2008). Before reviewing its definitions, it is worth commenting on New Zealand's drinking culture in general. The country's drinking profile falls into the category of a *dry*, *episodic*, or Nordic drinking culture where alcohol is separated from everyday life and used to mark celebrations and the end of work. This is in contrast with a *wet*, *integrated* or Mediterranean style where alcohol use is better integrated into everyday life (Fox, 2015). At the aggregate level, wet drinking cultures have higher proportions of violence attributable to alcohol than dry cultures (Room & Rossow, 2001). New Zealand's drinking profile is very clearly aligned with a wet style where drinking is episodic or "binge-oriented" (Fox, 2015): people appreciate alcohol's positive social effects, but show considerable tolerance of drunkenness and many drinkers seem to exercise little self-control over their drinking (McMillen et al., 2004).

The key feature of binge drinking is high volume consumption within a restricted time period, but definitions vary widely. The studies reviving the term "binge" to its modern usage (Wechsler et al., 1994; Wechsler et al., 1995) refer to consuming large volumes in a short time period. These studies covered 140 university campuses in the U.S., and used the 5/4 definition, where binge drinking is characterised by consuming 5 or more drinks for men, or 4 or more drinks for women, on a single occasion in the past two weeks. The sex-specific cut-offs account for differing rates of metabolism for alcohol between men and women (Wechsler et al., 1995). This widely used definition does not specify a time frame beyond a "single occasion" although this affects the rate of intoxication and toxic effects. It also asks questions in reference to the past two weeks, which could underestimate prevalence (Vik, Tate, & Carrello, 2000). Other terms such as Heavy Episodic Drinking and Risky Single Occasion Drinking are also used, sometimes interchangeably (Murgraff, Parrott, & Bennett, 1999), despite using vague time frames of *drinking occasions* and using varying cut-offs (Gmel, Kuntsche, & Rehm, 2011). A further complication is that academic definitions often differ from those used in public health and by central government agencies (Herring et al., 2008), which differ again from drinkers' understandings. Drinkers typically use behaviour-based definitions, such as drinking to get drunk or feeling out of control, rather than public health definitions, which rely on alcohol volume (Murugiah, 2012). In assessments, drinkers are often inaccurate because of their differing understandings of what a standard drink is (New Zealand drinkers and binge drinkers consistently underestimate their consumption), or what constitutes a drinking occasion (Fryer, Kalafatelis, McMillen, & Palmer, 2004). With

these considerations in mind, definitions of binge drinking should ideally be quantifiable, and cover drinking quantity, time-frame for drinking (drinking rate), and frequency of such a pattern (Babor et al., 2010; Courtney & Polich, 2009). For example, the definition proposed by the U.S. National Institute of Alcohol Abuse and Alcoholism (NIAAA; 2014) uses a definition 5 or more U.S. standard drinks for males and 4 for females in 2 hours (or an amount that takes blood alcohol content to 0.08%). This is a good start, but characterises one binge drinking episode and does not specify the frequency necessary to be considered a binge drinker. Another quantifiable definition uses items from the Alcohol Use Questionnaire (Mehrabian & Russell, 1978) to calculate a *binge score* from items measuring drinking, rate, times drunk in the past six months, and percentage of times that drinking leads to getting drunk (Townshend & Duka, 2002). Binge scores have also been used in conjunction with AUDIT scores to define binge drinkers in longitudinal research (López-Caneda, Rodríguez Holguín, Corral, Doallo, & Cadaveira, 2014). Unlike the NIAAA's definition, the binge score definition addresses long-term patterns by referring to a past-6 month window, the most instructive time frame for capturing links between consumption and related problems (Courtney & Polich, 2009). It also uses cut-offs to designate binge drinkers (scores of 24+) and non-binge drinkers (scores of 0–16). This is the measure used in the current study for its long frame of reference, clear cut-off scores and ability to address the recommended definitional aspects, although for review purposes a wider net was necessarily cast to include definitions that would benefit from more information being provided.

1.1.3. Alcohol-related harm in binge drinking

Although muddied somewhat by varying definitions and measurements of binge drinking, the literature points to increased risk associated with binge drinking episodes and binge drinking as a pattern. It is very similar to a hazardous pattern, as defined by the AUDIT (Babor, Higgins-Biddle, Saunders, & Monteiro, 2001), meaning that it poses risk to the physical, mental and even social health of the drinker, and possibly others. Acute intoxication from high volumes, even at relatively low frequencies, can lead to physical harm from accidents, injuries, and interpersonal violence, as well as risk of acute tissue damage (Babor et al., 2010). The Harvard "College Alcohol Study" (Wechsler et al., 1994) saw binge drinkers reporting a range of alcohol-related problems, ranging from hangovers and injuries, to missed classes, unplanned or unprotected sexual activity and getting in trouble with campus security or police. Frequent binge drinkers were more likely to experience these problems than infrequent binge drinkers, and the study found a linear relationship between

the number of drinks consumed consecutively and the number of alcohol-related problems experienced. Electrophysiological measures support and complement these behavioural indications of harm by detecting functional deficits related to alcohol use, including those that may not yet be evident at the behavioural level. A review of these electrophysiological studies supports the previously reviewed evidence that repeated fluctuation between intoxication and withdrawal, as seen in binge drinking, appears to have especially damaging consequences (Petit, Maurage, et al., 2014). These measures can also provide a sensitive measure of the effects associated with a sustained binge pattern. Maurage, Pesenti, Philippot, Joassin, and Campanella (2009), for example, showed that electrophysiological response latencies to auditory stimuli worsen as the binge drinking pattern continues. This difference was not detected by behavioural measures but event-related potentials (ERPs) revealed a binge-related impairment also seen in long-term alcohol dependence. The detrimental effect of continued binge drinking on functional abilities is replicated in follow-up studies spanning two to three years, such as those assessing attention, working memory, and response inhibition (López-Caneda et al., 2013; López-Caneda et al., 2012; López-Caneda et al., 2014).

Electrophysiological measures have also detected impaired neural attentional processing, impaired visual working memory, impaired facial detection processing, and poor response execution and inhibition in binge drinkers – all impairments also seen in dependent drinkers (Petit, Maurage, et al., 2014). While most binge drinkers (89.5% in a U.S. study) are not alcohol dependent (Esser et al., 2014), the similarities in the structural and functional deficits found in binge and alcohol-dependent drinkers has led some researchers to support the continuum hypothesis (e.g., Enoch, 2006; McCarty et al., 2005; Wagner & Anthony, 2002) which argues that these drinkers represent two stages of the same phenomenon. This relates to the Everitt and Robbins (2005) theory of addiction as the shift from casual use to habitual use to dependence, in which control is lost as neural systems of reinforcement shift.

In spite of definitional and measurement challenges, the literature on binge drinking as a drinking pattern shows that it is associated with risks to physical, cognitive, and social health. Given that the impairments seen in binge drinkers are often seen in dependent drinkers, and knowing that these worsen with a continued pattern, binge drinkers could be an appropriate target for intervention as a sub-clinical, at-risk drinking profile.

1.2. Alcohol attention bias

Addictive behaviours are characterised by attention biases for cues related to the addictive behaviour (Field & Cox, 2008). For example, alcohol cues "grab the attention" of alcohol abusers more than they do for light drinkers or abstainers (Townshend & Duka, 2001). Although weaker for alcohol and tobacco than for caffeine and illicit drugs, there is a significant relationship between attentional bias and subjective craving (Field et al., 2009) and there is evidence that one excites the other (Field & Cox, 2008). For instance, seeing an alcoholic drink or a bottle opener can increase craving, which will make the individual more likely to focus attentional and cognitive resources on alcohol, and so the cycle continues.

1.2.1. Incentive-sensitisation theory and alternative theories of addiction

Attention bias for substance-related cues can be explained in terms of incentive-sensitisation theory (Robinson & Berridge, 1993). This theory of addiction posits that with repeated drug administration the dopaminergic response to the drug continues to increase for some individuals through a sensitisation process: an increased response with increased drug taking ("wanting"). The sensitisation process mediates another in which *incentive salience* is attributed to the drug and drug-related cues. Through Pavlovian conditioning, or associative learning, when drug-related cues (such as a bottle, or a spoon and syringe) are paired with the drug and the individual's sensitised response to, or wanting for, the drug, the drug-related cues are also able to activate neural circuits of reinforcement, and become appetitive and salient themselves, and motivationally relevant. Being more salient, they attract the user's attention at the expense of other stimuli, a phenomenon known as *attention bias*. Sensitisation increases incentive salience until wanting is much greater than "liking" for the drug, as liking is not sensitised in the same way. Wanting becomes excessive craving that persists in the face of negative consequences associated with drug taking (such as social costs or losing one's job). Attention bias plays an important role in this model as it develops from incentive sensitisation and also contributes to the sensitisation process by promoting cue approach (drug seeking and taking).

Other notable accounts of addiction include the habit learning theory of Everitt and Robbins (2005). This account contends that with repeated drug administration comes a shift from action-outcome learning (where actions are performed with the intention of obtaining a goal) to stimulus-response learning (where associated stimuli, such as drug paraphernalia, or a bottle of alcohol, can elicit a response). In this transition, drug seeking and drug use

becomes less dependent on the consequences and increasingly dependent on environmental cues so that behaviour becomes automatic and habitual. This learning theory of addiction would predict that attentional salience of drug-related cues results from the repeated pairing of the cue with the outcome, and does not consider motivation an essential component of habit learning.

Another prominent theory of addiction concerns reward dysregulation (Koob & Le Moal, 1997, 2001). This model also proposes a transition, from impulsive to compulsive use. Two opponent processes are at play: intoxication, associated with positive reinforcement (where the effects of drug use increase the likelihood of drug seeking and taking), and negative affect from withdrawal, associated with negative reinforcement (where drug use alleviates negative effects of withdrawal, increasing the likelihood of drug seeking and taking. These processes typically serve to regulate reward and achieve homeostasis but soon fail, leading to a downward spiral, or allostatic state, which manifests as compulsive drug seeking and a loss of control over this behaviour. In this model, sensitisation and the resulting incentive salience still play a role, but are more important to the early stages of the cycle, as might be seen in a non-dependent drinker, but become relatively minor, whereas counteradaptation processes are responsible for the changes in motivation for drug seeking and taking.

These theories of addiction, emphasising incentive-salience, habit learning, and the dysregulation of reward systems, while divergent in their focus, are not mutually exclusive (Everitt et al., 2008). The early role of sensitisation in the reward dysregulation theory is acknowledged as relevant to the early stages of vulnerability to drug taking (Koob & Le Moal, 1997). The theory of stimulus-response habits and the incentive-sensitisation theories both recognise incentive salience as contributing to drug seeking, but differ as to what is responsible for the critical shift to compulsive drug seeking. Incentive-sensitisation emphasises the attribution of incentive salience to unconditioned stimuli (drug-related cues) to engage motivational sensitisation, whereas habit learning emphasises the automaticity with which the drug itself triggers drug-related responses. In addition, each theory acknowledges the importance of loss of control over drug seeking and use in the shift from casual use to motivated, habitual, or automatic use, to addiction.

1.2.2. Attention bias

Substance users perceive drug-related cues differently to non-users: they show evaluative biases for drug-related stimuli, perceiving them as more pleasant and attractive

(Mucha, Geier, & Pauli, 1999), and attentional biases where these stimuli selectively command attention. This can be assessed with a modified-Stroop or addiction-Stroop task where participants are asked to name the colours of addiction-related words while ignoring the text. Attention bias on such tasks is inferred from slower reactions to positively valenced words (that is, more attractive or motivationally relevant words, such as drug-related words) as they are thought to encourage more automatic readings and require more cognitive resources to ignore (Cox, Fadardi, & Pothos, 2006). Attention bias effects are found with this paradigm for dependent drinkers (Cox, Blount, & Rozak, 2000; Ryan, 2002), heavy drinkers (Cox, Yeates, & Regan, 1999), and for non-dependent drinkers with high AUDIT scores, a measure of harmful drinking (Sharma, Albery, & Cook, 2001). Cox, Hogan, Kristian, and Race (2002) further showed that in-treatment dependent drinkers' attentional distraction for alcohol stimuli was greater than for stimuli relating to other personal concerns. The alcohol-Stroop task is one of the most widely used measures of substance-related attention bias, but the interpretation of this indirect measure has been called into question. Klein (2007) showed that stimulus avoidance could cause slower processing times for alcohol words in abstinent alcoholics, a result that would normally be interpreted as an attentional bias for alcohol words. Another possibility is that the alcohol-related words induce craving, which adds to cognitive load by using processing resources (Tiffany, 1990) and thus slows down responses to these words (Field & Cox, 2008).

Tasks involving visuospatial cueing provide a more direct measure of attention bias. The visual dot-probe task is a common example, first designed to assess attention bias in emotional disorders, such as anxiety which is characterised by an attention bias for threatening over neutral stimuli, such as faces (MacLeod, Mathews, & Tata, 1986). The task presents a pair of pictures or words simultaneously, one disorder-related and one a neutral match (e.g., an alcoholic and a non-alcoholic beverage in the case of alcohol attention bias). Immediately after the stimulus pair disappears, a probe (a dot or an arrow) replaces the position of one of the stimuli. Reaction times indicate where attention was selectively focused at the time of stimuli offset/probe onset. Faster responses to probes replacing the disorder-relevant stimuli indicate that attention was more often on the disorder-relevant stimuli. Presentation times for the stimulus pair change the interpretation of the attention bias displayed. During a picture pair presentation lasting 200 ms, attention can shift once at most given the time it takes to attend to a visual stimulus, disengage, and shift attention to another stimulus. Therefore, attention can only be biased towards one stimulus category during this short presentation time. During a longer stimulus duration of 500 ms or more, attention can

shift several times, but reaction times to the probe will show where attention was focused when the probe appeared (at picture offset and probe onset). Tasks with picture durations of 200 ms or less are therefore thought to assess initial orienting of attention, and tasks with durations of 500 ms or more are best used to infer delay or difficulty in disengaging attention (Field & Cox, 2008). The more direct and nuanced measure of attention bias offered by visual probe tasks has been used to show attention bias for alcohol. Heavy social drinkers, for example, show alcohol attention bias when compared to occasional social drinkers (Townshend & Duka, 2001). Image presentations of 500 and 2000 ms in a dot-probe task elicited an attention bias in heavy social drinkers compared to light social drinkers, suggesting a difficulty in disengaging from salient alcohol cues (Field, Mogg, Zetteler, & Bradley, 2004). This bias was associated with craving for alcohol, as the incentive-sensitisation theory predicts.

Neurophysiological measures such as event-related potentials (ERPs) from electroencephalographic (EEG) recordings can also provide a measure of attention bias at probe onset (picture offset). Components such as the P1 and N1 waves, occurring around 80–130 ms and 140–200 ms respectively, show the distribution of attentional and central resources (Kok, 1997) and can index selective attention (Hillyard & Anllo-Vento, 1998). The amplitudes of these early components are greater when stimuli appear in attended locations than when they appear in unattended locations, and so are useful markers of initial attention orienting. More complex information processing is inferred from heightened amplitudes at later components such as the P3 (P300), a positive component occurring approximately 300–600 ms post-event, depending on the task and conditions (Kok, 1997). P3 is particularly sensitive to automatic processing of higher order characteristics, including motivational processing (Polich, 2007, 2012) and can be elicited in automatic detection conditions (Kok, 2001). Measurement of these ERP components can be integrated into visuospatial cueing paradigms such as a the dot-probe task so that behavioural reaction times can reveal where attention was selectively focused at stimulus offset, and probe-locked ERPs index attention bias at the same time. For example, Shin et al. (2010) used ERP data to investigate early attention orienting towards alcohol-related stimuli in drinkers with low and high sensitivity to the acute effects of alcohol (low sensitivity is a risk factor for dependence). Those with low sensitivity were faster to respond to alcohol-replacing probes, indicating an alcohol attention bias expressed at the behavioural level. ERP data supported this finding: these participants showed increased P1 amplitudes in trials where the probe replaced the alcohol-related image, indicating an orienting of attention to alcohol cues. A similar study investigating later

components found dependent drinkers had greater P3 amplitudes to alcohol-replacing probes than controls did (Namkoong, Lee, Lee, Lee, & An, 2004). P3 amplitude, associated with motivational processing, was correlated with craving. Binge drinkers also show higher P3 amplitudes in response to alcohol cues in a visual oddball task, which is interpreted as increased cue reactivity (Petit, Kornreich, Verbanck, & Campanella, 2013). Most relevant to the current study was an investigation into young college binge drinkers using behavioural and electrophysiological measures (Petit et al., 2012). Binge drinkers, when compared to non-binge drinking controls, showed increased parietal P1 amplitudes to alcohol-related stimuli in a visual oddball task, although no difference in behavioural measures of response latencies. This is a model experiment, which validated images using a pilot sample of 40 students, and critically had strict criteria for classifying binge drinkers that covered quantity, frequency and speed: binge drinkers were classified as drinking "six or more standard alcoholic drinks on the same occasion, three or four times maximum per week and, during these episodes, drank at a speed of consumption of at least three drinks per hour" (p. 928; this European standard drink definition corresponds to a standard drink in New Zealand, which is 10g of pure alcohol). These brief examples of baseline differences between drinkers and control show the advantage of ERP measures in being able to identify which stimuli attract attention preferentially, as well as the extent of complex motivational processing of those stimuli. They are also useful for measuring change over time in a binge pattern with more sensitivity than behavioural measures.

1.2.3. Attention bias modification

A study by MacLeod et al. (2002) showed that attention bias could be manipulated in non-anxious individuals by changing the position of the probe in a dot-probe task so that it replaced disorder-relevant stimuli on most trials. The manipulation (attention bias modification; ABM) successfully induced an attention bias in participants trained to attend to threatening stimuli. Anxious individuals showing an attention bias at baseline have also been trained to attend and to avoid threatening stimuli (O'Toole & Dennis, 2012), as shown in behavioural measures and in decreased P1 amplitudes to threat-replacing probes post-training. A "gamified" version of this ABM was presented in mobile application form to trait-anxious adults who showed reduced threat attention bias and reduced stress after a single session (Dennis & O'Toole, 2014). The training effect of ABM has been replicated with alcohol attention bias. A visual probe task successfully trained heavy social drinkers, half to avoid alcohol cues and the other half to attend alcohol cues (Field & Eastwood, 2005). The

attend alcohol group drank more alcohol afterwards and reported increased urge to drink while there was no difference in urge to drink for the avoid alcohol group. A more realistic comparison looks at the effects of training attention away from alcohol and compares it against a no-training control condition, as a later study did (Field et al., 2007). Training decreased attention bias, but craving for alcohol and alcohol consumption in a bogus taste test were unaffected in all groups. The inability of ABM's effects to extend to related issues such as craving is replicated elsewhere, such as in a group of heavy social drinking males (Schoenmakers et al., 2010). Training successfully reduced attention but symptoms of problem drinking were unaffected, such as craving or preference for alcoholic over non-alcoholic drinks. There are mixed findings on the generalisation of training effects, another clinically relevant feature, with support for generalisation to novel stimuli but not novel tasks by some (Field et al., 2007) and reports of no generalisation in heavy drinkers elsewhere (Schoenmakers et al., 2007).

Single session ABM training is sufficient to produce a difference in attention bias for training groups, but there are conflicting accounts of the effect sizes for alcohol ABM. A recent review found no significant effect of ABM for substance use on either attention bias or symptom reduction (Mogoaşe, David, & Koster, 2014), although this examined few studies. One of the more extensive meta-analyses considering ABM for threat and appetitive stimuli found an effect of training on appetitive attention bias, which was large when comparing two active training conditions (e.g., train-towards and train-away) and small when comparing training against a control condition (no training; Beard et al., 2012). This review also found a small effect of training on subjective experiences, such as craving, only when two active training conditions were used. There is some evidence that the number of trials or sessions moderates training effects on attention bias for emotional disorders (Hakamata et al., 2010). Additionally, Hallion and Ruscio (2011) showed a suggestive non-significant trend, although the studies contributing to this finding mostly used non-clinical samples. Beard et al.'s (2012) meta-analysis found that more training sessions resulted in greater effect sizes on subjective outcomes. Examples of multiple session alcohol attention bias retraining include a cognitive bias modification programme, the "Addiction Attention-Control Training Program", based on retraining alcohol approach responses, which was used with a community sample to successfully reduce the alcohol attention bias of hazardous drinkers after two sessions and reduce that of harmful drinkers after four sessions (Fadardi & Cox, 2009). Training of the harmful drinkers, who showed the greatest baseline attention bias, also led to decreased alcohol consumption. This group's improvements were maintained at a 3-month follow-up.

Schoenmakers et al. (2010) trained in-treatment dependent drinkers over five sessions with a cognitive bias modification programme, which decreased attention bias for alcohol and reduced relapse rates 3 months later. However, craving was unaffected by treatment.

This brief review shows alcohol bias modification can reduce attention bias for alcohol in a range of drinkers, from healthy to at-risk and dependent, with occasional evidence of its ability to affect alcohol consumption and subjective measures of craving. Although treatment effects have been reported to be modest, the advantages of ABM being a focused intervention that can be delivered at low cost through computerised tasks with little or no clinician involvement highlight its potential as an adjunct treatment or intervention to be coupled with another that can reach craving in particular.

1.3. Sense of control

Sense of control is a construct closely related to alcohol and substance use. Drinkers, including binge drinkers, tend to have a low sense of control, but this is amenable to change through simple interventions. Increased sense of control in these groups is associated with decreased craving in particular, something that attention bias modification has not reliably been shown to alter.

1.3.1. Relationship between control and substance use

Control is a construct key to our understanding of drug use and addiction. Substance dependence is the shift from controlled to compulsive drug use through loss of control over drug seeking and use behaviours (Everitt & Robbins, 2005; Robinson & Berridge, 1993). This is also indicated in the 5th Diagnostic and Statistical Manual's classification of Alcohol Use Disorders where the first grouping of diagnostic criteria represents impaired control, such as consuming alcohol in greater volumes or over longer periods than planned (American Psychiatric Association, 2013).

Many terms related to control overlap to some degree (e.g., self-efficacy, locus of control, intrinsic versus extrinsic motivation, learned helplessness), but one concept that appears especially relevant to drug use is a personal sense of control. Locus of control is a commonly used term, describing the extent to which an individual views outcomes and rewards as resulting from, or being contingent on, their behaviours rather than outside forces (Rotter, 1966). However, this one aspect of control is unidimensional in that it focuses only on contingencies (the relationship between responses and outcomes) and neglects competence

or capabilities (effectiveness of trying to bring about desirable outcomes and avoid or minimise undesirable outcomes). By contrast, sense of control includes views about the self and the environment – about competence and contingencies (McKean Skaff, 2007) – by including "a view of the self as competent and efficacious and a view of the world as structured and responsive" (Skinner, 1996, p. 559). As a multidimensional construct, sense of control can offer a picture of perceived overall and domain-specific control. Domains relevant to drug use might be body, mind, and impulse control, all of which are covered by the Shapiro Control Inventory (SCI; Shapiro, 1994). A New Zealand study, for example, found increased daily alcohol use to be associated with reduced sense of control in specific domains, including the domain of the self as measured on the SCI (Surgenor, Horn, Hudson, Adamson, & Robertson, 2006).

Sense of control is associated with health generally. A perceived sense of control, even when that control is not exerted, can have psychological and cognitive advantages, such as increased tolerance for frustration in aversive situations and improved accuracy in a cognitive task (Glass, Singer, & Friedman, 1969), as well as benefits to physical health (Langer & Rodin, 1976). Conversely, a decreased sense of control is associated with poorer health outcomes for the elderly (Rodin, 1986), and fatalism (the belief that one has no control over events in one's life) can predict difficulty in cognitive abilities and general illness long-term at 20-years follow-up (Caplan & Schooler, 2003). The relationship between control and health factors extends to alcohol use. There is a predictive association between self-control and drinking behaviours, as shown in the Dunedin Multidisciplinary Health and Development Study (Moffitt et al., 2011). Participants were assessed for self-control, a construct related to personal sense of control (Skinner, 1996), at ages 5, 7, 9, and 11 years, and those who showed low self-control as children were at increased risk in adulthood for substance use disorders. In student drinkers, having higher sense of control is associated with lower habitual consumption, as well as greater adaptive motivation ("a committment to pursuing realistic goals that are likely to succeed and likely to bring emotional satisfaction", Fadardi et al., 2001, p. 398; Shamloo & Cox, 2010). The relationship between sense of control and drinking extends to clinical populations too, such as a group of alcohol users attending alcohol/drug services in New Zealand (Surgenor et al., 2006). Among this group, severity of dependence was related to general sense of control, and daily use was related to specific control issues (lower overall sense of control, heightened sense of losing control in areas where individuals used to have control, and reduced sense of control in specific domains).

1.3.2. Sense of control manipulations

Sense of control can be manipulated, and manipulated in ways that are relevant to drinkers. A common method for investigating the effects of low control relies on the idea of ego depletion. This proposes that the ability to resist an urge is a finite resource and tasks that require exertion of control, such as suppressing a readily available thought or controlling laughter, will deplete control (Baumeister, Bratslavsky, Muraven, & Tice, 1998; Baumeister, Vohs, & Tice, 2007). Thought suppression, a form of active mental control and a popular method for manipulating mental control (Wenzlaff & Wegner, 2000), has been used to induce low self-control in heavy social drinkers (Palfai, Monti, Colby, & Rohsenow, 1997). Participants instructed to suppress thoughts of and urges for alcohol were faster to access alcohol-related information in their responses to a task afterwards than participants in a control condition. This finding might be a better indication that suppressing alcohol-related thoughts will encourage their stronger return later (a phenomenon known as "thought suppression rebound") rather than that low control was the source of the increased availability of alcohol information. If so, this points to the relative ineffectiveness of ignoring or suppressing urges. Nevertheless, depletion methods that are not alcohol-specific also show effects on alcohol behaviours and alcohol-related cognitions. For example, social drinkers completing a non-alcohol-related thought suppression task consumed more alcohol afterwards and reached higher blood alcohol content levels (Muraven, Collins, & Nienhaus, 2002). This effect was particularly strong for participants who had high trait temptation for alcohol, and the effect was resistant, evident despite an incentive to limit alcohol intake. Likewise, Teunissen and colleagues used another depletion method which asks participants to exert control over emotion expression while watching an emotive film to induce low control in heavy drinkers (Teunissen, Spijkerman, Schoenmakers, Vohs, & Engels, 2012). Participants scoring high on the Obsessive Compulsive Drinking Scale—that is, drinkers who reported high craving and motivation for alcohol—showed increased attention bias for alcohol after the manipulation. This suggests that low self-control itself is associated with greater attention bias and that increasing sense of control may be beneficial for those with greater alcohol craving and persistent thoughts about alcohol. There are some criticisms of the strength model of self-control contesting that control is not simply a finite resource, but in the absence of mediating effects such as those of emotion (Tice, Baumeister, Shmueli, & Muraven, 2007) and expectancies about control (Martijn et al., 2002), tasks requiring exertion of control appear to affect the ability to exert control in a subsequent task. The studies briefly

reviewed here show that processes and behaviours relevant to alcohol use, including attention bias and consumption, can be influenced by manipulating sense of control. An intervention target might then be to take advantage of the alcohol–control link and experimentally increase sense of control to improve outcomes.

A few studies have used the control literature to develop experimental conditions to induce a high sense of control for use with drinking samples. These are stronger pieces of evidence than the studies relying on ego depletion theory to explore the effects of reduced control because the mechanisms are clearer: they aim to increase sense of control by encouraging the participant's sense of being an effective agent and a view of the environment as responsive to their efforts. In a series of four studies in 2007 in an unpublished doctoral dissertation, Shamloo (as cited in Fadardi et al., 2011) showed that increasing sense of control can have clinically relevant outcomes. Shamloo instructed social drinkers to complete two cognitive tasks (anagrams and concept identification cards, the latter originally used to study uncontrollability and learned helplessness), with changes to the task instructions and procedures that would increase, decrease or not affect participants' sense of control. In the high sense of control group, participants were given motivational techniques including a choice of the task order, a chance to set task-related goals, a time limit, information enhancement (i.e., how to go about solving problems and achieve goals), encouragement, and immediate and contingent performance feedback. With these additions, the high sense of control group was more successful in the cognitive tasks, completing them in less time and with fewer errors, and also scored higher on task-specific adaptive motivation. Importantly, they reported weaker urges to drink alcohol and showed less alcohol-related attention bias as measured by an addiction-Stroop task. Another study confirmed these results were due to the manipulations and not changes in mood. A further study revealed that information enhancement and information enhancement with goal setting were the most effective conditions in producing sense of control. The combination was especially effective at a 45-day follow-up. The components of Shamloo's intervention are found elsewhere in the control literature showing improved health outcomes. Choice, for instance, has been an important element in interventions designed to increase sense of control and therefore psychological and health outcomes in elderly nursing home residents (Langer & Rodin, 1976; Schulz, 1976) with evidence of long-term maintenance of intervention effects (Rodin & Langer, 1977) and evidence of decline once choice was taken away (Schulz & Hanusa, 1978). Even the sense of control that comes with a choice over task order in two cognitive tests can reduce physiological measures of anxiety, in spite of the knowledge that it would not affect scores on

those tasks (Stotland & Blumenthal, 1964). Being reminded that a task is one a participant can improve on because it is skills-based, and therefore responsive to their efforts, increases sense of control too (Phares, 1957). Previously Shamloo (2007, as cited in Fadardi et al., 2011) had identified targets for change, such as feelings of low control attributed to not knowing how to achieve goals, and feeling that luck or change played a part in goal attainment, which the components of information enhancement and reinforcement address. Immediate, contingent, and positive reinforcement reward effort through operant conditioning, and also address views about competence and contingencies that are essential to sense of control (McKean Skaff, 2007) by reinforcing the idea of the participant as efficacious and of the environment as responsive to their efforts and actions (Skinner, 1996).

The manipulations used by Shamloo's initial studies were replicated with a sample of moderate drinkers, for which more detailed results on sense of control are available (Shamloo & Cox, 2014). Using the same task components of choice, goal setting, information enhancement, and positive contingent feedback, participants were assigned to conditions of high sense of control, low sense of control or no change. Participants in the high sense of control condition showed increased positive sense of control and decreased negative sense of control as measured by a task-specific version of the SCI, and the low sense of control group showed the reverse. Compared against the low sense of control group and, most appropriately, the no change group, the high sense of control group performed better on the concept card task used during delivery of the manipulation, and showed increased adaptive goal-seeking behaviour. Notably, this study also found that the high sense of control group showed decreased urge to drink and decreased attention bias as measured on the addiction-Stroop after the intervention. The attention bias finding was interpreted as an implicit measure of urge to drink, given the role of attention bias in drug seeking and craving.

There is some evidence that interventions designed to increase sense of control can decrease craving for alcohol and decrease attention bias in social drinkers. This intervention effect has been demonstrated with social drinkers and replicated once with moderate drinkers whose drinking habits were within U.K. guidelines for safe drinking, both times researched by the originator of the novel intervention. This finding requires further replication to investigate whether these findings apply to other drinkers, using more appropriate measures of attention bias than the indirect addiction-Stroop measures, such as a visuospatial cueing paradigm.

1.4. Statement of the problem and the combined intervention

Cognitive programmes to modify attention bias (ABM) can reduce alcohol attention bias in a variety of drinkers, but with small effect sizes and inconsistent findings on its ability to affect craving for alcohol. These limitations coupled with the advantages of it being easily standardised with a focused target for change and low running costs highlight its potential as an adjunct treatment. A promising complement to alcohol-related ABM is a sense of control intervention. Increasing sense of control has been reported to decrease craving and alcohol attention bias, and so could address ABM's shortcomings in affecting craving and boost the effects of ABM on attention bias. Sense of control training and attention training could be easily combined and, if ordered in this way could have impacts beyond the sum of their parts: the training to increase sense of control described by Shamloo and Cox (2014) also improved task performance and adaptive motivation, which could strengthen the effects of subsequent attention training.

Binge drinkers are a valuable group with which to trial a combined intervention as their drinking pattern puts them at risk for physical, mental, and health effects. Additionally, non-dependent binge drinkers are a sub-clinical group and thus a safer group with which to explore the effects of such an intervention (especially if not including a "low sense of control" condition, but just comparing a "high sense of control" group against an untrained control group), and yet because they share features with dependent drinkers it is possible that they could identify interventions worth investigating with dependent drinkers. Finally, with binge drinkers impairments and training effects can be detected sensitively with electrophysiological measures such as event-related potentials and functional magnetic resonance imaging (Petit, Maurage, et al., 2014), thus providing insight into the neural mechanisms mediating maladaptive responses and their potential modification.

1.5. Hypotheses

1.5.1. Hypothesis 1: Attention bias in binge drinkers

Unresolved question: Apart from a model experiment reporting an attention bias for alcohol in binge drinkers based on data from event-related potentials (Petit et al., 2012), the question of whether binge drinkers show attention bias for alcohol in the way that a range of other drinkers are reported to has not satisfactorily been answered. Additionally, asking this

question is necessary to consider the effect of attention training or sense of control training on attention bias.

Hypothesis: Binge drinkers show greater attention bias for alcohol-related cues than non-binge drinkers.

Rationale: Incentive sensitisation theory predicts that binge drinkers, as a result of cue learning and sensitised neural responses through repeated drug administration, are likely to have attributed incentive salience to alcohol-related cues, manifesting in an attention bias for these cues (Robinson & Berridge, 1993). Attention bias tends to be proportional to the frequency and quantity of substance use (Field & Cox, 2008), as incentive salience increases with each occasion of substance use, and thus non-binge drinkers are expected to exhibit less attention bias for alcohol than binge drinkers. The literature on alcohol attention bias shows this positive relationship between attention bias and pattern severity in a range of drinkers. For example, heavy drinkers focus visual attention on alcohol-related cues more than light drinkers (Field et al., 2004; Townshend & Duka, 2001). In binge drinkers, evidence of attention bias for alcohol-related cues has been reported in a study of event-related potentials (Petit et al., 2012).

Significance: This would provide support to the previous report of attention bias in binge drinkers (Petit et al., 2012), and illuminate the extent to which the effects of binge drinking are similar to those of other drinking patterns. Furthermore, this finding could inform intervention targets for binge drinkers as an at-risk group.

Proposed study: Binge drinkers' and non-binge drinkers' baseline alcohol attention bias will be compared using a visual dot-probe task. Attention bias for alcohol is reflected behaviourally by faster reaction times to probes replacing alcohol-related cues than reaction times to probes replacing neutral cues. In event-related potentials, attention bias is indexed by higher P1 and N1 amplitudes to probes replacing alcohol-related cues.

1.5.2. Hypothesis 2: Effect of ABM on binge drinkers' attention bias

Unresolved question: Previous studies have shown that attention bias for alcohol can be manipulated through ABM (e.g., Field et al., 2007; Schoenmakers et al., 2007), but there are no reports of applying ABM to binge drinkers, specifically, to reduce alcohol attention bias.

Hypothesis: Binge drinkers receiving attention training through ABM will show a greater decrease in attention bias than untrained binge drinkers and untrained non-binge drinkers. Futhermore, binge drinkers receiving the combined intervention (sense of control

training and attention training) will show a greater decrease in alcohol attention bias than binge drinkers receiving only one type of training or no training.

Rationale: Training selective attention away from alcohol-related cues has previously been able to reduce alcohol attention bias in heavy drinkers (e.g., Field et al., 2007) and dependent drinkers (e.g., Schoenmakers et al., 2007). Binge drinkers given sense of control training are expected to see particular benefits in reduced attention bias as the sense of control training itself has also been reported to decrease attention bias (Shamloo & Cox, 2014), and is further expected to make the subsequent ABM training more effective through improved task performance (discussed in Section 1.5.4).

Significance: Identifying a treatment effect in binge drinkers could point to attention bias as an underlying neural mechanism contributing to the harm associated with this pattern of alcohol consumption, and suggest a target for harm reduction interventions.

Proposed study: In groups receiving training, probe placement in the visual dot-probe task will be manipulated to more often replace the neutral cue, as opposed to the 50/50 probe placement for groups not receiving training that is also used to assess attention bias at pre-test and post-test. Attention bias scores and the P1 and N1 amplitudes considering probe type will be assessed between pre- and post-test. Statistical interactions between experimental group and test would indicate a treatment effect.

1.5.3. Hypothesis 3: Effect of sense of control training in increasing sense of control

Unresolved question: Sense of control training, which uses simple cognitive tasks to deliver the intervention elements of choice, information enhancement, goal-setting, and positive, contingent reinforcement, can increase sense of control in moderate drinkers (Shamloo & Cox, 2014), but has yet to be replicated. Further, it is unknown whether these effects on sense of control would be seen in binge drinkers.

Hypothesis: Binge drinkers receiving sense of control training will report a greater increase in personal and task-specific sense of control than participants who do not receive sense of control training.

Rationale: The sense of control intervention reported by Shamloo and Cox (2014) relies on the link between control and alcohol consumption accounted for in theory, such as the understanding of addiction as a shift from casual to compulsive use through a loss of control (Everitt & Robbins, 2005), and seen in practice, such as the observation of low sense of control relating to higher alcohol consumption (Shamloo & Cox, 2010). Intervention elements are drawn from a wide literature on sense of control, and were shown to increase

task-specific sense of control in a sample of moderate drinkers (Shamloo & Cox, 2014). The current study extended the focus to include personal sense of control too.

Significance. A finding in support of the sense of control training's ability to increase sense of control would replicate results reported with moderate drinkers (Shamloo & Cox, 2014), and suggest that this intervention could be useful for a range of drinkers in addressing the lack of control related to maladaptive substance use. In addition, it would allow for the interpretation that training effects are a result of increased sense of control.

Proposed study. Simple cognitive tasks, namely, anagrams and concept identification cards, will be completed while the intervention elements are delivered. Binge drinking participants given sense of control training will perform these tasks with the added elements of choice over task order, information enhancement, goal setting, and positive reinforcement contingent on behaviour. Binge drinkers given sense of control training will be compared against untrained participants on personal and task-specific sense of control, measured before and after the intervention tasks.

1.5.4. Hypothesis 4: Effect of sense of control training in improving task performance

Unresolved question: The effect of increasing sense of control on improving task accuracy, reported by Shamloo and Cox (2014), has yet to be replicated. Further, it is unknown whether these effects, shown in moderate drinkers, will extend to a sample of binge drinkers.

Hypothesis: Binge drinkers receiving sense of control training will complete the anagram and concept identification cards tasks more quickly and more accurately than untrained binge drinkers and untrained non-binge drinkers.

Rationale: The sense of control intervention described by Shamloo and Cox (2014) is thought to increase sense of control by encouraging feelings of success on the tasks used, which should be reflected in task performance as improved task speed and accuracy.

Significance. Improved task performance would provide a rationale for placing the sense of control training before an adjunct intervention, or even applying the sense of control training intervention elements directly to the adjunct treatment.

Proposed study. Participants' speed and accuracy in the anagram and concept identification cards tasks will be assessed between the first and last trials when the intervention elements will be added for participants receiving training.

1.5.5. Hypothesis 5: Effect of sense of control training in decreasing craving

Unresolved question: The effect of increasing sense of control on decreasing craving for alcohol, reported by Shamloo and Cox (2014), has yet to be replicated. Further, it is unknown whether these effects, shown in moderate drinkers, can be extended to a sample of binge drinkers.

Hypothesis: Binge drinkers receiving sense of control training will report a decrease in craving for alcohol not reported by untrained participants. Futhermore, binge drinkers receiving the combined intervention (sense of control training and attention training) will report lower levels of craving than participants receiving only one type of training or no training.

Rationale: Sense of control training takes advantage of an observed negative relationship between alcohol consumption and sense of control (Shamloo & Cox, 2010) and a negative relationship between consumption severity and sense of control (Surgenor et al., 2006). Low sense of control can increase the urge to drink, perhaps by activating automatic action schema (Tiffany, 1990) or in a considered effort to relieve negative affect associated with low sense of control, and thus increasing sense of control may decrease alcohol craving. An intervention to increase sense of control has been shown to decrease explicit craving for alcohol in moderate drinkers (Shamloo & Cox, 2014). The combined intervention is expected to be especially effective in reducing craving because, in addition to the reported effect of increasing sense of control on reducing urges to drink, ABM is expected to retrain attention away from alcohol-related stimuli and thus minimise any cue-elicited craving.

Significance: The limited ability of ABM to reduce subjective craving (Beard et al., 2012) is a particular weakness given the excitatory relationship that exists between attention bias and craving (Field et al., 2009), which affects drug seeking and drug use. If sense of control training can address this shortcoming by decreasing alcohol craving, it follows that sense of control training could be a useful complement to attention bias training.

Proposed study: Time-locked craving will be assessed before and after the sense of control intervention tasks, and binge drinkers receiving sense of control training will be compared with participants who are not given sense of control training.

1.5.6. Hypothesis 6: Effect of interventions on alcohol consumption

Unresolved question: As a combined intervention aiming to decrease attention bias and craving, the latter by way of increasing sense of control, has not previously been tested, the

effects of these interventions on alcohol consumption in a post-training challenge are unknown. The utility of a combined intervention in reducing binge drinkers' alcohol consumption is similarly unknown.

Hypothesis: Binge drinkers receiving attention training or sense of control training will consume less alcohol than participants receiving no training. Futhermore, binge drinkers receiving the combined intervention (sense of control training and attention training) will consume less alcohol than binge drinkers receiving only one type of training or no training.

Rationale: This hypothesis is motivated by previous findings that increasing alcohol attention bias can increase the motivation to consume alcohol (Field & Eastwood, 2005), and that attention bias retraining can reduce alcohol consumption in a subsequent taste test challenge (Field et al., 2007). The effects of increasing sense of control on alcohol consumption have not been reported, but given the negative relationship between alcohol consumption and sense of control (Shamloo & Cox, 2010), the sense of control training was expected to decrease alcohol consumption. The combination of interventions is expected to have an additive effect of decreased craving and decreased motivation to drink, from the control intervention, and decreased attention bias for the alcoholic drink and its related cues, from the attention training.

Significance. The findings regarding alcohol consumption, tested in a bogus taste test, can point to a practical value of the combined or individual interventions' treatment effects.

Proposed study. Participants' alcohol consumption will be tested under the guise of a taste test in which participants will be asked to sample one alcoholic and one non-alcoholic beverage. The quantities consumed will be measured and compared between experimental groups.

The study design is detailed in Section 2.1.

2. METHOD

2.1. Design

This study used a factorial design with one between-subjects variable, Group Treatment, with five levels, and one within-subjects variable, Test, with two levels (pre- and post-tests). Attention training and sense of control training are levels of the Group Treatment factor, and the independent variables embedded in the Group factor. For baseline comparisons of the two drinking groups, Group became a two-level factor to compare binge drinkers (pooling four groups together) and non-binge drinkers. Primary dependent variables were changes in attention bias scores, changes in personal and task-specific sense of control, changes in craving ratings, and amount of beer consumed in the taste test. Other variables of interest were baseline sense of control, baseline craving and baseline attention bias scores for the comparison of binge drinkers and non-binge drinkers.

Binge drinking participants were assigned to one of four Group Treatments, in which the attention intervention and control interventions tasks were delivered with or without training. The fifth group, non-binge drinkers or "controls", completed both interventions without training to act as a "pure control" for direct comparison with Group 4 (no training). Groups are shown in Table 1. Group assignment was pseudorandom, balancing for age and sex across all groups, and balancing for Alcohol Use Disorder Inventory Test (AUDIT) scores and binge scores across the binge drinking groups, as participants enrolled in the study.

Table 1. Experimental groups and Intervention levels.

Experimental group	*n*	Drinking group	Sense of Control Intervention	Attention Intervention	Group treatment
1	10	BD	Training	Training	Combined intervention
2	10	BD	No training	Training	Attention training only
3	10	BD	Training	No training	Sense of control training only
4	11	BD	No training	No training	Untrained binge drinkers
5	10	C	No training	No training	Untrained non-binge drinkers

An initial power analysis was not possible due to the large number of dependent variables used and the lack previous studies investigating such variables in a population of

binge drinkers. However, previous ABM studies using experimental group sizes of 20 (e.g., Field et al., 2007; Field & Eastwood, 2005) were able to detect medium to large effect sizes. Given the restrictions of some participants' need to travel and limitations on compensation available, 15 participants per group was the initial target. Despite great interest in the study and many eligible participants, recruitment yielded only 10 or 11 participants per experimental group.

While not a possibility for the current study due to somewhat limited participant enrolment rates, a counterbalanced design would have allowed for generalisations about presentation order. However, the control intervention was ordered first because of the findings of Shamloo (2007, as cited in Fadardi et al., 2011; Shamloo & Cox, 2014) that indicated the sense of control intervention could improve task accuracy and speed, and it was thought that this could improve performance and therefore effectiveness of the attention intervention task if placed before it. Shamloo also reported in the initial series of studies that participants receiving the brief intervention showed less alcohol-related attention bias as measured by an addiction-Stroop task, and so it was thought attention training might be especially effective if preceded by sense of control training (Group 1).

2.2. Participants

A total of 51 participants (31 females and 20 males) completed the experiment. Of these, 41 were binge drinkers, divided into four BD experimental groups, and 10 were non-binge drinking control participants (Group 5). The final participant pool had an average age of 22.24 (SD = 5.28), with no significant difference in the distribution of age between experimental groups, $H(4) = 0.35$; $p = .987$, or the two drinking groups, $U = 203$; $p = .962$. Groups comprised six females and four males, except Group 4 which had an additional female. This difference was considered small enough to be acceptable in terms of the male to female ratio. One-way ANOVAs showed that BD groups did not differ on AUDIT scores, $F(3, 37) = 0.27$, $p = .846$, or binge scores, $F(3, 37) = 0.63$; $p = .602$. Binge drinkers differed from non-binge drinking controls on both counts (AUDIT: $t(49) = 7.25$; $p < .001$; Binge score: $t(49) = 8.54$; $p < .001$). Experimental groups were appropriately balanced for demographic variables of age and sex, and drinking groups were appropriately different for comparison on drinking variables. Descriptive information on the groups is presented in Table 2. Participants were tertiary students (various institutions; from post-secondary to post-graduate; $n = 46$) and full-time workers ($n = 6$).

Eligibility required being between 18 and 50 years of age, and being classified as either a binge drinker (binge score of 24 and above) or a non-binge drinker ("control"; binge score of 16 or below). Exclusion criteria included a reported family history of alcoholism, reported current psychiatric or regular recreational drug use (to limit possible effects of psychological disorders or psychiatric medication on ERPs), or scores above 20 on the AUDIT (a threshold warranting further "diagnostic evaluation for alcohol dependence", Babor et al., 2001, p. 20). AUDIT and binge scores have previously been used together to categorise binge drinkers in longitudinal research (López-Caneda et al., 2014).

Table 2. Descriptive statistics for demographic and drinking variables.

Group	*n*	Age		AUDIT scores		Binge scores		Sex ratio (F:M)	Smokers
		Mdn	interquartile range	*M*	*SD*	*M*	*SD*		
1	10	21.5	1	10.70	4.42	41.04	17.46	6:4	0
2	10	21.0	5	12.30	4.17	40.60	7.03	6:4	2
3	10	21.5	6	11.50	4.30	38.36	9.01	6:4	1
4	11	20.0	4	11.27	3.20	34.82	10.71	7:4	0
5	10	22.0	5	2.10	2.08	6.54	5.02	6:4	0
BDs	41	21.0	4	11.44	3.92	38.61	11.54	25:20	3
Cs	10	22.0	5	2.10	2.08	6.54	5.02	6:4	0
Total	51	22.0	4	9.61	5.20	32.32	16.62	31:24	3

Participants were recruited though advertisements on university and polytechnic campuses, on online noticeboards for students and research participants, at public libraries, shopping centres and community centres, and in community newsletters. Notices directed interested participants to a website which provided further information about the study and offered a screening survey to determine eligibility. Some of those interested who did not have reliable internet access responded for screening by phone or visited the laboratory for in-person screening. A recruitment notice is shown in Appendices

The screening survey, made using Qualtrics (www.qualtrics.com), collected demographic information and administered the AUDIT and AUQ-derived binge score questions in order to determine eligibility. Qualifying respondents were able to provide their

contact details in the survey for more information and to sign up for a testing session. Respondents meeting exclusionary criteria were filtered out and informed so without specifying the particular reason for exclusion. These respondents were informed that either they met an exclusionary criteria listed on the information page (e.g., age) or sufficient participants with responses like theirs had already been recruited. This was to discourage respondents from retaking the survey with altered answers in order to be accepted. Appendix B. shows the screening survey.

The screening survey was started 649 times and 426 surveys were completed. Of these respondents, 144 were identified as eligible binge drinkers and 170 as eligible controls, and 113 binge drinkers and 100 controls expressed interest in participating and entered their details. All interested and eligible participants were invited to enter in the study. The total number of participants who signed up and arrived for testing was 41 binge drinkers and 10 non-binge drinking controls from a waiting list to match the number of binge drinkers in an experimental group.

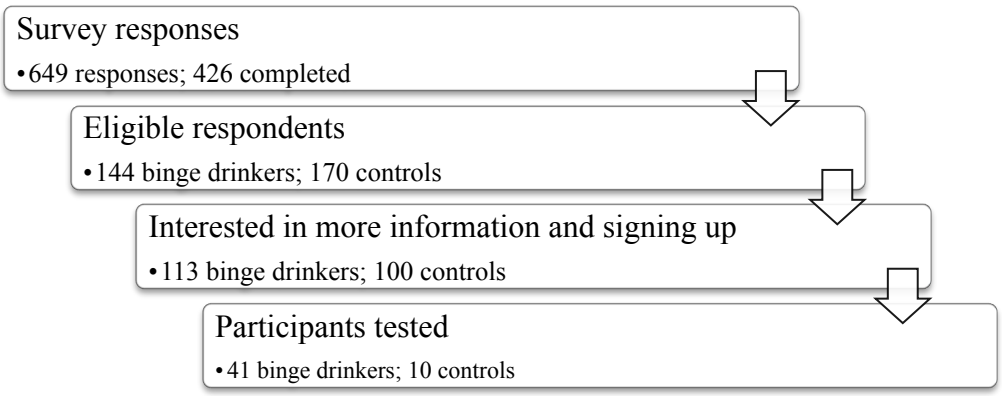


Figure 1. Responses at stages of the screening process.

After screening and before arranging a testing session, participants were sent an information form (Appendix C.) with more information about the study, most of which was presented at the start of the screening survey. Informed consent was obtained with a consent form (Appendix D.) presented at the start of the testing session. This study was reviewed and approved by the University of Canterbury Human Ethics Committee (16 July 2014, reference: HEC 2014/54).

2.3. Apparatus and EEG

2.3.1. Stimuli

Stimuli were prepared and presented with E-Prime (Professional suite; run-time version 2.0.10.353; Psychology Software Tools, Inc.) and displayed on a Phillips Brilliance 225B 22-inch monitor (resolution 1860 × 1050). Participants sat approximately 60 cm from the screen. Event triggers were coded into the ABM task in E-Prime and sent via an Input/Output port to a second computer which recorded the EEG data with Neuroscan version 4.4 (Compumedics Neuroscan).

2.3.2. ERPs

2.3.2.1. Recording

EEG data were recorded using an electrode cap arranged in the international 10-20 system (64-channel Quik-Caps; Compumedics Neuromedical Supplies, Abbotsford, Australia). Electrode placement is shown in Figure 2. Electrode set-up initially used Quik-Cells placed in electrode wells with liquid electrolyte delivered via a blunted tip syringe. This was replaced after Participant 13 by the use of conductive electrolyte Quik-Gel (Compumedics) which was found to deliver lower impedances and thus improve the signal-to-noise ratio and was faster to prepare.

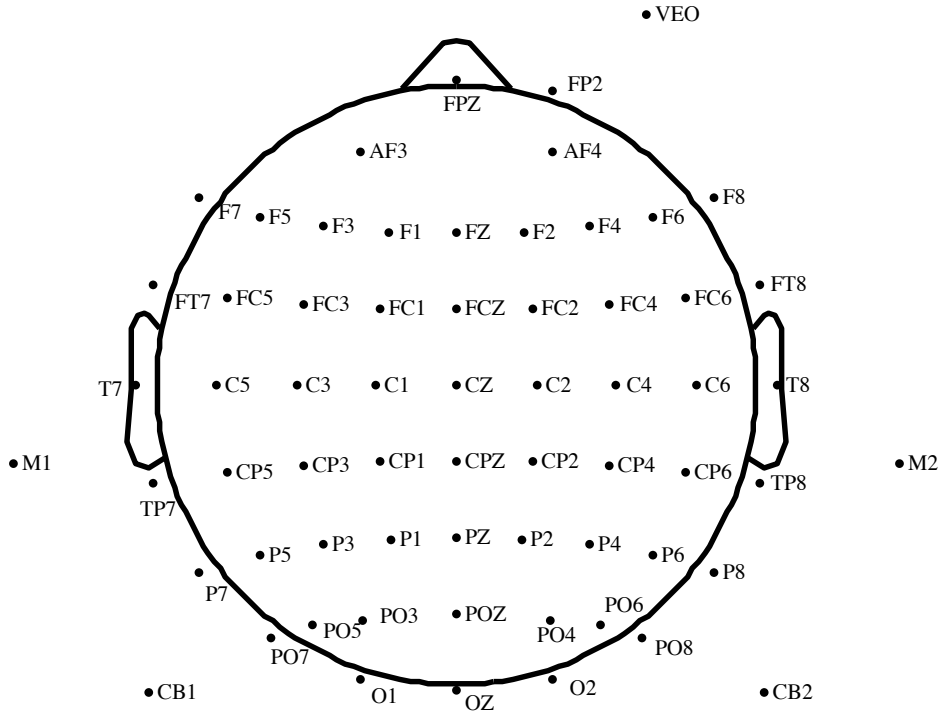


Figure 2. EEG electrode placement using the international 10-20 system.

Electrodes were referenced online to a central midline electrode (between Cz and CPz). All 64 channels were set-up and recorded from where possible. Final sites for analyses included Pz, Fz, a parietal cluster ("PCluster") made by averaging sites P5, P3, P1, Pz, P2, P4, and P6, and a frontal cluster ("FCluster") made by averaging sites F5, F3, F1, Fz, F2, F4, and F6. These sites were chosen to reflect areas of maximal amplitude: changes in P1 and N1 indexing attention orienting are greatest over the posterior, including parietal sites (Heinze, Luck, Mangun, & Hillyard, 1990), and changes in P3 reflect frontal attention processing (Polich, 2007). Blinks and vertical eye movements were monitored using an electrode above and below the left eye (bipolar VEOG). As the behavioural task and presentation required no horizontal eye movements and given the participants' distance from the monitor, HEOG was not monitored. A Neuroscan SynAmps amplifier (Compumedics) was used to amplify EEG and EOG signals which were filtered online at 1.0–40 Hz at a sampling rate of 1000 Hz. Median impedances were calculated for each participant at pre- and post-test. Due to a Neuroscan error, impedance data was not recorded for some participants (n = 3). Of these values, the median pre-test impedance was 15 kΩ (range 7 to 73) and post-test impedance median was 14.5 kΩ (range 7 to 74).

2.3.2.2. Offline data processing

Offline data processing was performed using MatLab (Version 2014b) with the EEGLab and ERPLab plug-ins. EEG data were filtered at 1 Hz to 30 Hz (48 dB) and re-referenced to an average mastoid reference. EEG data were epoched into 2 s windows and each epoch underwent rigorous processing to identify channels with poor data (referred to as *bad* channels) as follows. To identify artefacts from electrode movement or electrode pop, absolute values of channel amplitudes that exceeded a 300 μV threshold were marked as bad for that epoch, as were channels with a constant amplitude lasting for 1000 ms or longer. To detect single-channel, single-epoch artefacts (such as those resulting from a short loss of electrode contact or burst of white noise from transient electrical faults), channel variances and median slopes were both transformed into z-scores. Where either or both of these absolute z-scores were greater than 4, the channel at that epoch was marked as bad (Nolan, Whelan, & Reilly, 2010). Last in the epoch-by-epoch processing, the correlations of each channel with its interpolation based on other good channels was calculated. When this correlation failed to meet the threshold of .5, the epoch was marked as bad (using a recursive approach to avoid excessive removal of channels whereby the channel with the lowest correlation in each iteration was marked bad until the minimum correlation of .5 was

achieved). Where 40% or more of an epoch's total channels were marked as bad from any of the above steps, the epoch was rejected entirely; otherwise, bad channels were interpolated.

As independent component analysis (ICA) is sensitive to noisy data, data were next processed to identify "all-channel" noise in an epoch, which typically comes from participant movement or resulting electrode movement. The parameters described by Nolan et al. (2010) were calculated to detect electrode movement on the scalp and changes in electrode voltage off-sets (examining amplitude range in an epoch), from shifting electrodes (deviation from the channel average in an epoch), and from subject movement (variance in an epoch). These noisy epochs were removed. In final preparation for ICA, principal component analysis (PCA) was first run to correct for the linear dependency between channels ("rank deficiency") that was introduced by the epoch-level interpolation. PCA was applied to reduce the data's dimensionality to 16, and then ICA was applied to the output. The independent components produced were analysed to identify those that came from ocular or EMG artefacts (Section 3.2.3 in Nolan et al., 2010). Final EEG data had artefacts removed and noisy epochs rejected.

Coded event triggers were emitted with every probe in the ABM task (approximately 61 alcohol-replacing probes and 61 neutral-replacing probes, at both pre-test and post-test, making a total of 244). These triggers were used to create the ERPs. An average of 12 trials per participant were rejected through the above data processing, and an average of 229 trials total were accepted and used for group averaging. This breaks down into an average of 57 trials per condition (alcohol- or neutral-probe, at pre- or post-test). Grand averages were created using weighted averages based on the number of trials.

2.4. Interventions

2.4.1. Sense of control intervention

The control intervention was operationalised by the experimental manipulation of additional instructions. These manipulations (choice, goal-setting, information, emotional control and reinforcement) followed the high sense of control condition described by Shamloo and Cox (2014). Participants in the sense of control training groups completed the intervention tasks (anagrams and concept identification cards) with additional instructions from the experimenter. Participants (a) chose the order of the tasks, (b) were asked to set goals with time limits, (c) received information about the task nature (i.e., hints about effective solving strategy), and (d) received positive reinforcement that was immediate and

contingent on their performance. Groups not receiving training completed the anagrams and concept identification cards without instructions beyond the practice blocks, i.e., (a) no choice of task, (b) no goal-setting, (c) no hints or information, and (d) no feedback on performance.

2.4.2. Attention bias modification

The attention intervention was operationalised by attention re-training blocks in the ABM task. Attention training groups were trained in the five blocks between the pre- and post-tests to attend to the neutral images. This was achieved by manipulating the arrow probe to replace the neutral image 80% of the time. For groups not receiving attention training, the probe replaced the neutral images 50% of the time, in all blocks. A no-training group was used (e.g., Schoenmakers et al., 2007) as it is a more realistic comparison group than training participants to attend to the alcohol-related stimuli, as some others have done (e.g., Field et al., 2007; Field & Eastwood, 2005).

The current study was not able to use an independent blind experimenter to administer the manipulations, but precautions were taken to standardise the testing sessions and reduce bias from the researcher acting as experimenter. An experimental script (Appendix E.) was used to guide instructions and verbal administration of control training additional instructions. Manipulation checks were also included: Attention training participants were asked if they detected a pattern in the task, and specifically with regard to the arrow probe, and participants completing the taste test were given a chance to identify what was really being tested. A manipulation check for the sense of control training was not specifically tested although there was an opportunity during the debriefing for participants to comment on the control intervention tasks. Those who correctly identified the manipulations were excluded from the relevant analyses.

2.5. Measures and materials

2.5.1. Drinking behaviours: risk of harm and binge drinking

The Alcohol Use Disorders Inventory Test (AUDIT; Saunders et al., 1993) is a screening test of alcohol consumption covering hazardous alcohol use, symptoms of dependence and harmful alcohol use (i.e., intake, behaviour and problems). The 10 items are each scored 0–4, giving a possible total of 40. A score of 8 or higher indicates hazardous drinking, an established pattern of drinking that puts the drinker at high risk for damage to

physical or mental health (although it may not yet have resulted in adverse effects). The scale is designed for cross-national use (Babor et al., 2001), and has been validated for Māori, European, and Pacific peoples (Ministry of Health, 2013a). There is evidence of its reliability (test-retest and internal consistency data) and of its validity (content, criterion, and construct data; Connors & Volk, 2003). The AUDIT was used in the current study as a measure of risk of alcohol-related harm, and to exclude participants with scores over 20 who warrant further assessment for possible alcohol dependence (Babor et al., 2001).

Binge scores capture the pattern of drinking, rather than volume or risk of harm. Following Townshend and Duka (2005), binge scores are calculated using the final three items of the Alcohol Use Questionnaire (AUQ; Mehrabian and Russell, 1978) which measure drinking speed (drinks per hour), number of times drunk in the past 6 months, and the percentage of times drinking leads to getting drunk. The original scoring is applied to these three items, where they are weighted with a factor loading and summed [(4 x Item 10) + Item 11 + (0.2 x Item 12)]. Using the criteria of Townshend and Duka (2005), binge scores greater than or equal to 24 identify binge-drinkers, scores less than or equal to 16 identify non-binge drinkers, and scores between these values are considered to be in a buffer range and unclassifiable.

2.5.2. Sense of control

The Shapiro Control Inventory (SCI; Shapiro, 1994) is a 187-item multidimensional measure of control. From the full inventory the current study used the subscales addressing general-domain sense of control (Positive, Negative and Overall) and Desire for control, each comprised of items scored on 7-point Likert scales running from 1 (*Never*) to 7 (*Always*). The Positive Sense of Control subscale (11 items) measures perceived self-efficacy, the ability to set and achieve goals, and attaining and an appropriate level of self-control. The Negative Sense of Control subscale (5 items) measures aspects such as lack of or loss of control, and too much control from external sources. Overall Sense of Control combines the Positive and Negative scales (reversing the polarity on the Negative scale) to be used as the broadest view of a participant's sense of control. Finally, Desire for Control (11 items) pertains to motivation for achieving and maintaining control. The SCI has been validated for use with clinical, at-risk, and non-clinical populations, including adult children of alcoholics as an at-risk population, with robust evidence of its reliability and validity (Shapiro, 1994).

2.5.2.1. Validation

To measure within-subjects change, two summary measures were developed to assess briefly overall sense of control and task-specific sense of control (in relation to the sense of control intervention tasks and the attention intervention tasks). This follows Shamloo and Cox (2014) who developed a task-specific control inventory (TSSCI) covering the Positive, Negative and Overall subscales, although their definition of overall sense of control aligns better with Shapiro's domain specific sense of control. The summary measures developed for the current study used the SCI's Positive, Negative and Desire For Control subscales. A total of 5 items with good face validity were selected for further reliability checks using the SCI data from a pilot group (n = 12; 3 males and 9 females; mean age 23.36, range 18-29).

The 5-item summary scale correlates strongly with the Overall sense of control scale (r =.966; Cronbach's α = .983) and has good internal consistency (α = .818). The inter-item correlation is moderate (r = .543) and slightly weaker than that of the Overall SCI subscale (r = -.653) because of the presence of the reverse-coded Negative SCI subscale item. This summary measure was applied to personal sense of control (Summary-SCI) and reworded to apply to task-specific control (TSSCI), following Shamloo and Cox (2014).

2.5.3. Craving

The Penn Alcohol Craving Scale (PACS; Flannery, Volpicelli, & Pettinati, 1999) is a 5-item scale used to assess past-week craving for alcohol. Items use 7-point Likert scales (e.g., "During the past week *how much time* have you spent thinking about drinking or how good a drink would make you feel?" with possible answers from 0 (*none at all*) to 6 (*more than 6 hours*). The PACS has been used to test medicinal treatments' effects on craving, and has good validity and some reliability data (National Institute of Alcohol Abuse and Alcoholism, 2003).

A time-locked craving question (time-locked craving; TLC) was used to measure within-subjects changes over the two interventions. The TLC asks about strength of current urge to drink on an anchored scale of 0 (*not at all*) to 10 (*extremely*) and provides a more time-sensitive measure than the PACS. A TLC measure has previously been used in other ABM studies to assess transient changes (e.g., Field & Eastwood, 2005).

2.5.4. *Ad-libitum* consumption

Ad-lib consumption of alcohol was measured in a voluntary "taste test" in which participants sampled an alcoholic and a non-alcoholic drink to fill out a bogus taste test

survey while the experimenter covertly measured amounts consumed. This method was first developed by Marlatt, Demming, and Reid (1973) where the amount of alcohol beverages consumed is taken as an unobtrusive and indirect measure of motivation drink. Variations include the availability of an alternative, usually non-alcoholic, beverage to control for thirst and to more closely resemble animal models (A. Jones et al., 2015). It has since been used to investigate influences on alcohol consumption and to establish proof of concept for novel behavioural interventions similar to the current study (Field & Eastwood, 2005; A. Jones & Field, 2013). The taste test is not influenced by time of day or day of week, as drinking outside the laboratory is, but does reflect consumption volume outside the laboratory, and the test has established construct validity (A. Jones et al., 2015).

In the current study, participants were presented simultaneously with 200 ml of orange juice (Just Juice 50% less sugar orange fruit flavoured drink; Frucor Beverages Ltd., New Zealand) and 200 ml of beer (Lion Brown draught beer, 4.0% alcohol; Lion, New Zealand) in clear glasses on a silver tray, with the taste test survey set up on a nearby computer (created using a Qualtrics survey, shown in Appendix F.). Participants were instructed to "have as much or as little as [they] would like to be able to answer the questions". The survey asked participants to rate each drink on three characteristics (after-taste, bitterness, sweetness, and strength) using a simple three-point scale of *too much*, *just enough* or *not enough*. A final question asked for an opinion of overall pleasantness for each drink, marked as a percentage. Taste characteristics and the scale were taken from Allison & Uhl (1964), where they had originally been selected along with other characteristics based on strong agreement between beer drinkers about their meanings and the ability of those beer drinkers to identify and rate them. Amounts consumed were measured after the participant left and expressed as alcohol drank as a percentage of total fluid consumption.

2.6. Tasks and stimuli

2.6.1. Anagrams

As in Shamloo and Cox (2014), the anagram task was included as a vehicle over which to deliver the sense of control manipulation (choice, information enhancement, goal-setting, and positive reinforcement) to participants receiving sense of control training. This task presents a string of letters which can be rearranged to make a word in English which participants are instructed to identify.

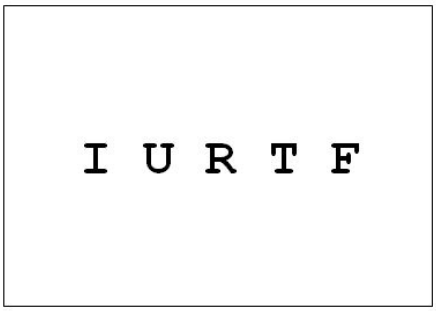


Figure 3. Example trial of the anagram task. In this example, the solution is "fruit".

Anagrams for use in the sense of control intervention were generated based on the method described in Shamloo and Cox (2014). Words were extracted from a frequency list of written and spoken English based on a 2001 version of the British National Corpus (Leech, Rayson, & Wilson, 2001) in three categories: easy (frequency of 40–50 per million), moderate (20–40) and difficult (10–20). Shamloo and Cox (2014) used the categories of 40–50, 10–39; and 5–9, but this more modern corpus reports words with a frequency of 10 per million and higher, so frequency categories were adjusted.

Words within each frequency category's limits were extracted and made into a list of random order. Working from the top of this list, words meeting the criteria were selected until enough words were chosen to make five sets of five anagrams, each containing one easy, two moderate, and two hard words, each having the same amount of total letters. The final words had no obvious priming effects and were not related to the study (e.g., "health", 246 per million nouns was excluded), and had no repeated letters. Once word lists were compiled, the letter-strings of the words were rearranged with random shuffle orders: 43251 for 5-letter words, 342516 for 6-letter words and 3652714 for 7-letter words. Shuffle orders were generated with a randomizer tool (www.random.org). Jumbled letter strings were centred on the screen in capital letters (New Courier font, size 24) and a space was provided for participants to type in and review answers before submitting them, or to submit a blank answer for anagrams they could not solve. Anagrams are presented in Appendix G.

This largely follows the method used by Shamloo and Cox (2014), although the medium and difficult categories were defined using different word frequency values because of the different corpuses used. Words meeting the criteria (e.g., no repeated letters) were categorised for difficulty based on their frequencies and number of letters. The final set included some two-solution words instead of strictly single-solution anagrams as in Shamloo and Cox (2014). It was beyond the scope of the current study to consider concreteness,

imagery, and meaningfulness ratings of the words shortlisted for inclusion, as Shamloo and Cox (2014) were able to do, although it is recognised that these factors can influence the difficulty level of the resulting anagrams (Witte, Freund, & Csiki, 2002). Other factors could have also influenced the difficulty, such as the randomisation of the letter strings which would change the transition probability of letter pairs (the probability that a pair of letters will occur together in the English language). Although the current anagram set may have been more difficult than that used by Shamloo and Cox (2014), the words and their presentation order were consistent for all experimental groups. This may, however, have interfered with the sense of control intervention if improvements in performance would be more evident and easily measurable with a less difficult word set.

The anagram task involved five sets of five anagrams being presented on-screen until the participant typed in and submitted an answer or skipped that trial by submitting a blank answer. Each set of five was followed by a short break, the length of which was determined by the participants.

2.6.2. Concept Identification Cards (CIC)

As in Shamloo and Cox (2014), the concept identification cards task (CIC) was included as a vehicle over which to deliver the sense of control manipulation (choice, information enhancement, goal-setting, and positive reinforcement) to participants receiving sense of control training. This task uses cards depicting multidimensional stimuli (stimuli that vary along a dimension, such as shape or colour), originally used in studies of discrimination learning (Levine, 1966, 1971). Participants are presented with a pair of cards at a time and tasked with identifying which one dimension is common to both cards (e.g., both cards present striped stimuli).

Cards for use in the sense of control intervention were created for presentation on a computer screen. Replicating Shamloo and Cox's method, dimensions for card stimuli came from Hiroto and Seligman (1975) in their studies of uncontrollability and learned helplessness. Each card presented a stimulus of a geometric shape that varied along five dimensions, as presented in Table 3. An example trial is shown in Figure 4.

Table 3. Dimensions and values for Concept Identification Cards.

Dimension	Value one	Value two
Shape	Circle	Square
Colour	Blue	Orange
Pattern	Solid colour	Striped
Number of shapes	One	Two
Horizontal line	Above figure	Below figure

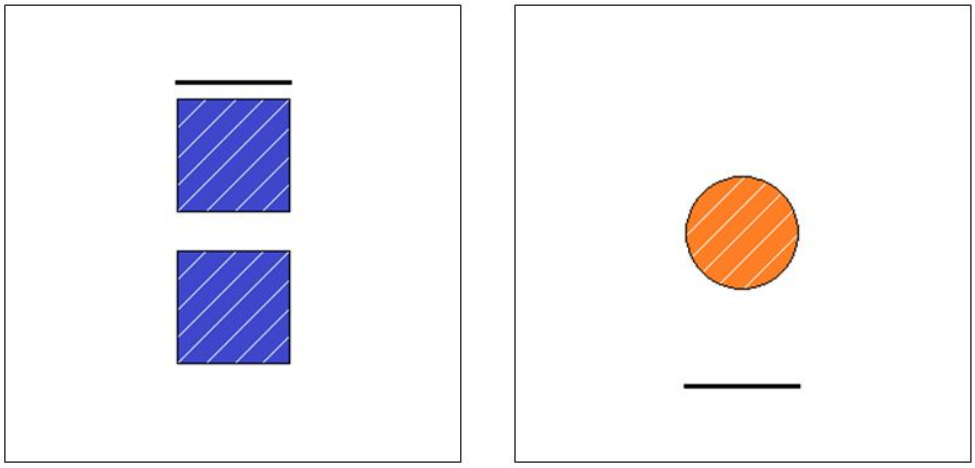


Figure 4. Example trial of the concept identification card task. In this example, pattern is the solution as it is the only dimension common to both cards (both stimuli are striped).

Cards were made on 300 x 300 px canvases and geometric shapes were 75 x 75 px and were centred in the canvas if single, or placed vertically in the centre with 25 px between them. Horizontal lines were 75 px across, 1 px wide, and placed 50 px from either the top or bottom of the canvas. The set of cards used is presented in Appendix H.

The CIC task was comprised of five sets of five cards each. Possible answers and the respective keyboard keys were listed along the bottom of the screen for reference. Each set of five was followed by a short break, the length of which was determined by the participants.

2.6.3. Attention Bias Modification (ABM) task

Attention bias for alcohol-related stimuli was assessed with a computerised modified dot-probe task, a version of which was later used as the retraining task. This paradigm starts with a centralised fixation cross lasting 1000 ms before an image pair appears, comprised of one alcohol-related and one neutral image (e.g., a beer can and a soft drink can). These

images appear simultaneously in a top-bottom formation (associated with stronger effect sizes in detecting a bias; Hakamata et al., 2010) and last for 500 ms. Next, an arrow probe (↑ or →) lasting 100 ms replaces either image (alcohol-probe or neutral-probe) in either position (top or bottom). The participant is instructed to focus on the fixation cross and to identify the orientation of the probe with an appropriate key press (the up or right arrow key) within 2 s. Figure 5 shows the presentation order of a trial in the ABM task. Only correct responses occurring between 200 and 2000 ms after presentation of the probe were considered.

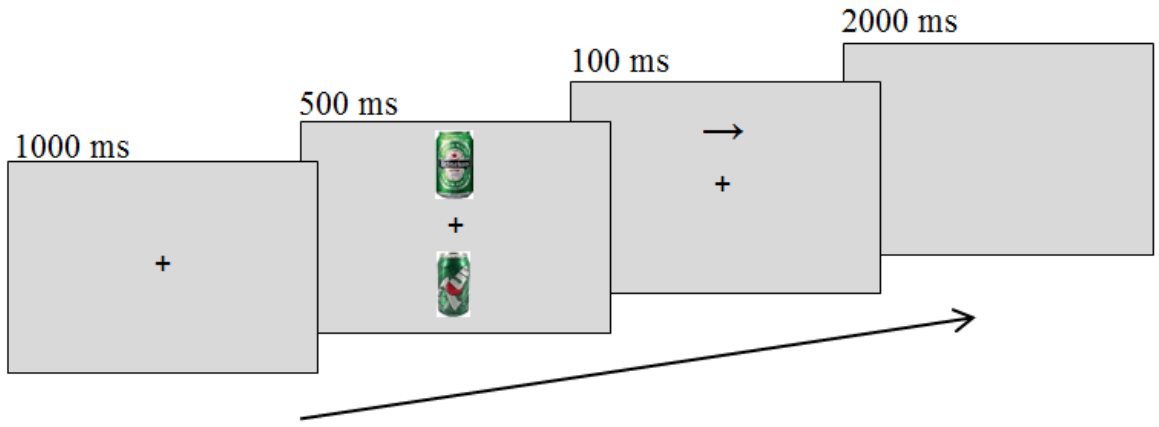


Figure 5. Sequence of events in a modified dot-probe trial for assessing alcohol attention bias. This example shows an alcohol trial, as the probe replaces the alcohol-related image.

An attention bias score is calculated by subtracting reaction times to probes replacing alcohol images from reaction times to probes replacing neutral images ($RT_{Neutral}$ - $RT_{Alcohol}$). Higher positive scores, from faster responses in trials where the probe replaces the alcohol image, indicate an attention bias towards alcohol. Because probe position is essentially random (alcohol images appear in the top position half the time in a random sequence, and probes replace alcohol images half the time, in a random order), faster reactions to one image type are understood to result from a selective attention being paid to those images before the arrow probe is presented.

As well as assessing attention bias, the modified dot-probe task can be used to re-train or modify attention bias away from or towards a stimulus category by changing the frequency with which the probe replaces images in that category. In the present study, attention training groups were trained to attend to the neutral images by having the probe replace the neutral

images in 80% of trials during training blocks. For those not receiving training the probe continued to replace the alcohol images in just 50% of trials.

Participants completed one practice round of 10 trials using "filler" images (neutral-neutral image pairs not used in the main task). The main task consisted of 7 blocks of 120 trials each. The first and last blocks acted as a pre- and post-test. These were identical, starting with two filler image trials to allow for false starts, before 120 critical trials in which probes replaced alcohol and neutral images 50/50. In the five middle blocks, attention training groups were trained by manipulating the arrow probe to replace the neutral image 80% of the time. Group receiving no attention training continued with the 50/50 probe positioning during these five blocks. ABM for trained groups and the original task without training for the untrained groups consisted therefore of 600 trials.

2.6.3.1. Images and validation

Forty image pairs (of one neutral and one alcohol image each) were created for use in this task. Alcohol images were selected to include easily recognisable, locally available brands. Neutral matches for alcohol-related images were sourced using Google's image search algorithms and "visually similar" search function with a category keyword and refined by eye for similar colours and composition. Irfanview was used to crop and resize images to a standardised height of 10 cm (378 px), and to edit images for brightness, contrast, and other colour corrections where necessary. Of the final 40, five pairs contained social cues or a human context (e.g., a hand holding a glass up to a mouth). Neutral images belonged to one of three categories: non-alcoholic drinks, for realistic alternatives to the alcoholic drinks (17 images), and for less appetitive and more emotionally neutral stimuli, furniture (18), and stationery (5). The practice block used five pairs of visually similar neutral images, developed in the same manner (e.g., a red pencil and a red ballpoint pen). These neutral-neutral image pairs were also used at the start of the pre- and post-test to prepare participants for the task. The full set of ABM images used is presented in Appendix I.

The 80 images were evaluated by a sample of 13 pilot participants (demographic information unavailable but mostly the same sample from the summary-SCI evaluations). Participants rated each image on dimensions based on the International Affective Picture System (Lang, Bradley, & Cuthbert, 1999): pleasantness (0 – *Unpleasant/Sad* to 9 – *Pleasant/Happy*) and arousal (0 – *Calm/Bored/Unaroused* to 9 – *Excited/Nervous/Aroused*). Alcohol-related images were rated for how much they made participants crave an alcoholic

drink on a scale of 0 (*not at all*) to 10 (*very much*). Nine participants answered all 200 questions on the 80 images and 4 gave partial responses.

Alcohol and neutral images were rated as similarly arousing, $t(39) = .55$, $p = .586$, but differed on ratings of pleasantness: alcohol images were rated as less pleasant than their neutral counterparts, $t(39) = -6.35$, $p < .001$. As for the neutral images chosen as visual matches for alcohol images, these differed on ratings of pleasantness, $F(2, 37) = 11.85$, $p < .001$ and ratings of arousal, $F(2, 37) = 41.46$, $p < .001$, depending on the category of the neutral images. Post-hoc Newman-Keuls tests revealed that neutral images from the Drinks category were rated as more pleasant than neutral images in the Furniture category, $p < .001$, and more pleasant than neutral images in the Stationery category, $p = .001$. Neutral images from the Furniture and Stationery categories were not rated differently from each other on pleasantness, $p = .873$. Post-hoc Newman-Keuls post-hoc tests revealed that neutral images from the Drinks category were rated as more arousing than both the Furniture category, $p < .001$, and more arousing than the Stationery category, $p < .001$. Furniture and stationery categories of neutral images were not rated differently from each other on arousal, $p = .619$

For neutral images, arousal ratings did not vary between images with and without social cues, $F(1, 38) = 0.93$, $p = .340$, and pleasantness ratings varied marginally, $F(1, 38) = 4.28$, $p = .045$, with higher pleasantness ratings being assigned to the images with social cues ($M = 5.31$, $SD = .35$) than images without social cues ($M = 4.91$, $SD = .42$). For alcohol images, there was no difference between images without and without social cues on ratings of pleasantness ($F(1, 38) = 1.20$, $p = .281$), arousal ($F(1, 38) = 1.05$, $p = .311$) or craving ($F(1, 38) = 0.70$, $p = .408$). The average craving rating for the alcohol images was 1.53 ($SD = 0.72$) out of a possible 10.

2.7. Procedure

Online screening surveys completed before testing collected baseline data. Testing sessions were held in the afternoon, starting between 12.00 and 14.00 and lasting for approximately two hours. Participants were tested individually in a 4 × 6 m experimental laboratory kept at 18–19°C, where only the researcher had contact with participants. The laboratory held two computers sat against opposite walls, one for stimulus presentation where the participant sat and the other for EEG recording where the researcher sat, unless delivering instructions or an experimental manipulation in which case the research sat next to the participant, also facing the stimulus presentation computer. The researcher first briefly

outlined the order of tasks (previously sent to participants, between screening and organising a testing session in an information sheet, shown in Appendix C.), explaining the researcher would first fit the EEG cap, then the participant would answer some personality-type questionnaires on the computer before completing two problem-solving tasks and one longer visual task. Informed consent was obtained through signing a consent form (Appendix D.) before continuing. The full procedure is shown in Figure 6.

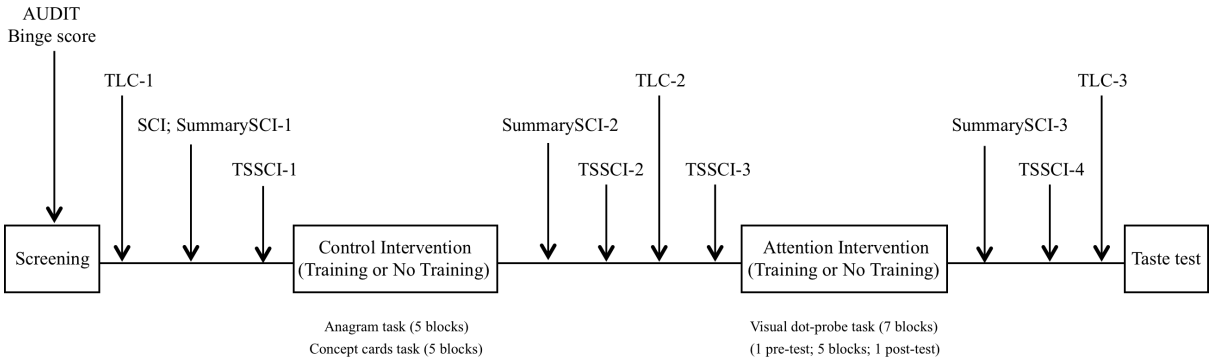


Figure 6. Experimental procedure.

The screening survey captured drinking variables with the AUDIT scale of hazardous drinking and the binge score. Craving was measured at baseline with the Penn Alcohol Craving Scale (PACS), and as a repeated measure with the time-locked measure (TLC). Sense of control was measured at baseline with the Shapiro Control Inventory (SCI). Repeated measured of sense of control focused on personal sense of control (SummarySCI), and task-specific sense of control (TSSCI).

2.7.1. Baseline measures and instructions

Participants were set up in the EEG cap and then completed baseline measures at time 1: the PACS, TLC-1, SCI. Next, all participants were introduced to sense of control tasks (the anagrams and concept identification cards) by the researcher who used examples of these tasks to explain. Participants were told that there would be a practice round for all tasks in the session. Participants completed the task-specific sense of control measure in relation to the anagram and concept card tasks (TSSCI-1). The SCI was used to calculate the Summary-SCI at time 1.

2.7.2. Control intervention

Next was the sense of control intervention in which the participants completed the anagram and concept card tasks, either with the extra features (choice of task, task information, goal-setting, emotional control, and contingent, positive feedback) for the sense

of control training groups, or without further instructions for the untrained groups. Following the sense of control intervention participants repeated the TSSCI for those tasks (TSSCI-2), repeated the Summary-SCI-2, and answered a time-locked craving question (TLC-2).

2.7.3. Attention intervention

The researcher introduced the attention bias modification task (ABM), using a snapshot of the task to explain, and reminded participants that there would be a practice round first. The next measure was a baseline task-specific control measure related to the ABM task (TSSCI-3). Participants were prompted to adjust the height of their chair so that their eyes were level with the centralised fixation cross, and were reminded of the task objective (responding to the orientation of the arrow probe) and to work quickly but accurately. After the practice round and 7 blocks of ABM, participants were asked to complete the final TSSCI measure, relating to the ABM task (TSSCI-4), a final personal sense of control measure (Summary-SCI-3), and a final craving measure (TLC-3).

2.7.4. Optional taste test

Participants were informed that that they had reached the end of the testing session but that they could volunteer to participate in an optional taste test which was described as being used to select the materials for a future study. Those who opted to participate (n = 38: 33 binge drinkers and 5 non-binge drinkers) were presented with the alcoholic and non-alcoholic drinks and instructed to have "as much or as little as [they] would like to be able to answer the taste test questions" which were open on a web-based survey using Qualtrics (survey shown in Appendix F.). Once participants had left the laboratory, the difference in the weight of glasses was recorded.

2.7.5. Debriefing

Participants were debriefed by the researcher who explained the aims of the study, the expected results, and the true nature of the taste test using the form in Appendix J. Participants were also told their binge scores and how it was used to classify them as a binge drinking or a non-binge drinking control participant, as well as their AUDIT score and sex-specific risk bracket using Health Promotion Agency material (low, medium, or high risk; MacEwan, 2003) for context of overall drinking pattern and likelihood of harm. The debriefing sheet also contained the websites and phone numbers of local alcohol and drug

services and websites for general information. Finally, participants were reimbursed for their time with a $20 supermarket, mall or petrol voucher.

2.8. Data analysis

An independent t-test was planned to compare baseline attention bias between the two drinking groups. One-way ANOVAs were planned to compare experimental groups on baseline craving and baseline task performance. Repeated-measures mixed ANOVAs were planned to assess any changes in alcohol-attention bias over the ABM task, changes in craving, personal sense of control and task-specific sense of control over the two interventions, and any training effects of the first intervention by comparing accuracy and reaction times between the second and last task blocks, as well as differences between the volumes of drink types consumed in the taste test. ANCOVAs were planned to replace ANOVAs to control for any covariates found if experimental groups differed significantly on those covariates. Post-hoc analyses of difference used Newman-Keuls tests.

The dataset was checked for normality and homogeneity of variances, using Shapiro-Wilks and Levene statistics, and skewness and kurtosis values, interpreted in conjunction with graphical data representations. Variables were assumed to be non-normal in cases where absolute z-scores for either skewness or kurtosis were greater than 1.96, as is recommended for small samples (Kim, 2013). This affected the time-locked craving data and reaction time and accuracy data for the anagram and CIC tasks, which were accordingly analysed with the non-parametric equivalents of the planned analyses.

Effect size estimates are reported for parametric statistics as Cohen's *d* values for main effects and partial η^2 for interaction terms. Partial η^2 (η_p^2) describes the proportion of variance explained by a variable when other variables in the analysis are excluded. For non-parametric test results, effect sizes were calculated with *r*, as described in Rosenthal, Rosnow, and Rubin (2000), as follows:

$$r = \frac{z}{\sqrt{N}}$$

where *z* is the test statistic converted into a *Z*-score and *N* is the study size (or number of observations in repeated measures). The effect size *r* translates to a "correlation between an individual's score on the dependent variable and the contrast weight assigned to the condition to which the individual belongs" (p. 73, Rosenthal & DiMatteo, 2001). This effect size is especially useful in the face of small sample sizes and limited statistical power to detect differences, and is easily interpreted in practical terms as it offers a constrained effect size

between -1 and 1. While effect sizes should be interpreted in context, Cohen (1992) suggests the following rules of thumb: r = .10 as small, r = .3 as medium, and r = .5 as large. For Cohen's d, d = 0.2 is considered small, d = 0.5 as medium, and d = 0.8 as large.

2.8.1. ERP data analysis

For comparison of drinking groups at baseline, an ANOVA was performed comparing N1 peak amplitudes with drinking group (BD or Control) as the between-subjects factor and probe position relative to the cue (probe replaces alcohol or neutral image) as the within-subjects factor in a 2 × 2 (Group × Probe) design. To look at the groups' change over the course of the task, Test (pre-test or post-test) was added as a within-subjects factor. Amplitudes were therefore analysed in a 5 × 2 × 2 (Group × Probe × Test) ANOVA. Significant effects were explored with post-hoc Newman-Keuls tests.

One participant from the non-binge drinking control group (Group 5) was excluded on account of noisy data with too many rejected epochs, so final analyses concerned 50 participants (41 BDs and 9 controls). Analyses were performed on electrode Pz, a parietal cluster ("PCluster", an average of sites P5, P3, P1, Pz, P2, P4 and P6), Fz, and a frontal cluster ("FCluster", an average of sites F5, F3, F1, Fz, F2, F4 and F6). Analyses used average ERPs smoothed with a moving window average of 50 ms to make the dominant peak amplitude of the waves more perceptible (Delorme, Miyakoshi, Jung, & Makeig, 2015). Amplitudes of N1 were defined for each participant (at each test and for each probe condition) as the most positive peak between 100 and 200 ms after the probe and P3 amplitude as the most positive peak occurring between 300 and 400 ms post-probe. For a small number of participants, N1 peak amplitudes fell before 100 ms after probe-onset (typically at 85 ms post-probe) and were identified manually.

3. RESULTS

This experiment was designed to investigate whether binge drinkers show greater alcohol attention bias than non-binge drinkers, and if attention bias can be decreased through training. It also aimed to replicate the sense of control intervention described by Shamloo and Cox (2014) with a sample of binge drinkers to see whether the manipulation could increase personal and task-specific sense of control and decrease craving for alcohol. Participants completing both the sense of control and attention bias training were expected to have better outcomes (lower craving, lower attention bias, and lower motivation to drink alcohol in the taste test) than those who completed just one intervention, and even more so than those who completed none.

Neurophysiological data was expected to support the behavioural hypotheses regarding attention bias. Attention bias for alcohol is indexed by larger N1 amplitudes to probes replacing alcohol cues than N1 amplitudes to probes replacing neutral cues – a difference that was expected to be greater in the binge drinkers than in the non-binge drinkers, if the latter group were to show a difference at all. The reduction in attention bias scores from pre-test to post-test expected for groups receiving the attention training was expected to be mirrored in decreased N1 amplitudes in response to alcohol probes from pre-test to post-test.

3.1. Behavioural results

Correlations of interest are presented in Appendix K.

3.1.1. Baseline differences in attention bias between drinking groups

Attention bias scores are calculated by subtracting the average reaction time to probes that replace alcohol-related images from the reaction time to probes that replace the neutral image, so positive values reflect a relative focus on alcohol-related images and negative values a relative focus on neutral cues. Attention bias scores for the two drinking groups are shown in Table 4, and for the five experimental groups in Figure 7. Appendix L. gives descriptive and test statistics. There was a non-significant trend for binge drinkers to have, on average, higher alcohol attention bias scores than non-binge drinkers, $t(49) = 1.68$, $p = .098$, $d = 0.57$. Binge drinkers tended to focus their attention more on the alcohol-related images (shown in the positive attention bias scores), whereas the non-binge drinkers tended to focus

attention more on the neutral images (shown in the negative attention bias scores). Binge drinking experimental groups (Groups 1–4) did not differ statistically from each other on attention bias at baseline, $F(3, 37) = 0.20$; $p = .895$.

Baseline attention bias scores tended to decrease with increasing age, $r = -.405$, $p = .009$, and to decrease with increasing AUDIT scores ($r = -.320$, $p = .041$). There was no significant relationship between attention bias scores on the ABM and participants' binge scores, $r = -.127$, $p = .430$.

Table 4. Baseline alcohol attention bias scores. Positive scores indicate a relative bias towards alcohol-related cues.

Drinking Group	*n*	Baseline Attention Bias Scores	
		M	*SD*
Binge drinkers	41	4.24	14.07
Non-binge drinking controls	10	-4.32	15.79

The hypothesis that binge drinkers would have greater attention bias than controls was not supported, although there was a trend ($p = .098$) in that direction.

3.1.2. Training effects of attention intervention on attention bias

A repeated-measures Time (pre- or post-) × Experimental Group ANOVA was performed. The main effect of Time was not significant, $F(1) = 3.81$, $p = .057$, $d = 0.58$, but showed a trend for attention bias scores to decrease from pre-test ($M = 2.56$, $SD = 14.66$) to post-test ($M = -3.66$, $SD = 18.99$). The Time × Group interaction was not significant, $F(1) = 1.40$, $p = .249$, $\eta_p^2 = .109$. The between-subjects factor of experimental group had no significant effect, $F(4) = 0.05$, $p = .995$, $d = 0.13$. Figure 7 shows the attention bias scores for each experimental group at pre- and post-test, and descriptive statistics are given in Appendix K. Positive scores reflect a relative focus on alcohol-related images and negative scores a relative focus on neutral cues.

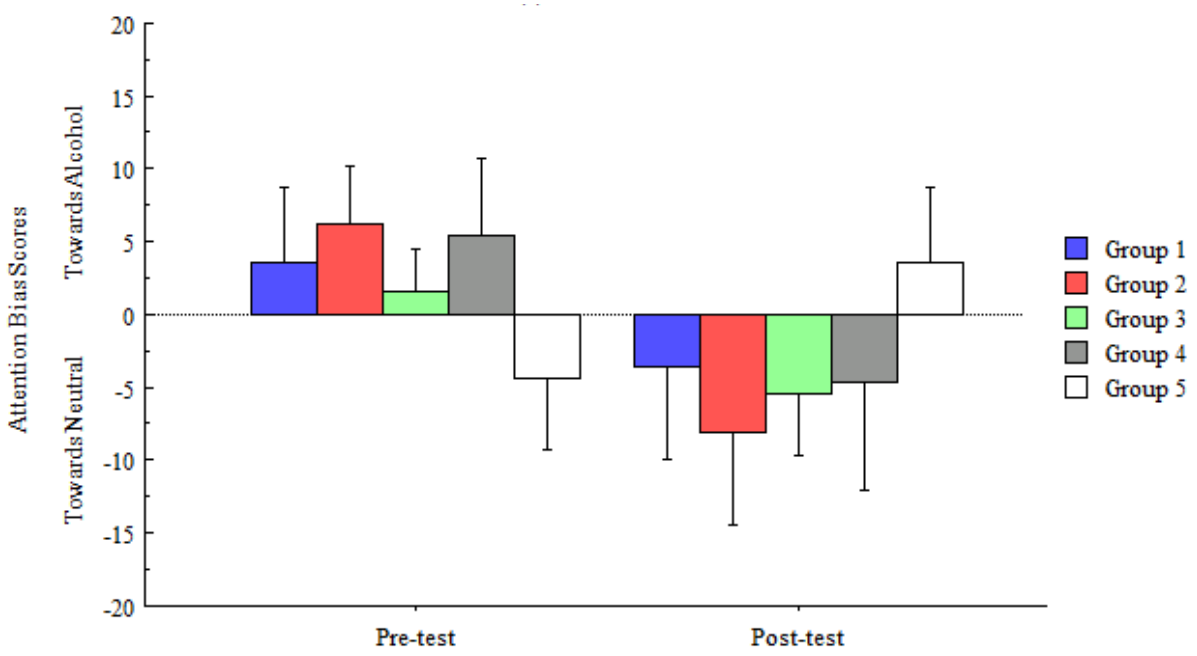


Figure 7. Attention bias scores at pre- and post-test. Error bars show 1 standard error.

The change in attention bias scores over time approached significance but was not supported statistically, and as there was no significant Time × Group interaction, there was no support for the hypothesis that attention training (Groups 1 and 2) could reduce alcohol attention bias.

3.1.3. Training effects of control intervention on personal and task-specific sense of control

Personal sense of control was measured with the Summary-SCI at three points: (1) before the sense of control intervention, (2) between the two interventions, that is, after the control intervention, and (3) after the attention intervention. Descriptive statistics for personal sense of control ratings by groups are presented in Table 5.

Table 5. Means and standard deviations for personal sense of control ratings.

Experimental Group	SummarySCI-1		SummarySCI-2		SummarySCI-3	
	M	*SD*	*M*	*SD*	*M*	*SD*
1	24.70	1.89	25.70	2.00	25.70	3.92
2	24.50	4.35	24.70	1.25	25.00	2.31
3	24.90	3.90	23.70	3.47	24.10	3.73
4	26.55	1.70	25.00	3.41	27.27	2.97
5	23.90	4.95	25.20	3.97	25.60	4.79
All participants	24.94	3.55	24.86	2.96	25.57	3.64

To look at change in personal sense of control over time, a 3 × 5 (Time × Experimental Group) ANOVA was performed. As the assumption of sphericity was violated, $W(5) = .621$, $p < .001$, results were interpreted using Greenhouse-Geisser corrections (Greenhouse-Geisser $\varepsilon = .725$, and falls within the recommended threshold for use of .75; Barcikowski & Robey, 1984; Huynh & Feldt, 1976). Results showed that personal sense of control scores did not change significantly over time, $F(5.801) = 0.33$, $p = .327$, $d = 0.307$. The Time × Group interaction was not significant, $F(5.801) = 0.86$, $p = .530$, $\eta_p^2 = .069$. The between-subjects factor of experimental group had no significant effect, $F(4) = 0.87$, $p = .491$, $d = 0.55$.

Task-specific sense of control was measured at four points: (1) before the sense of control intervention tasks, (2) after the sense of control intervention tasks, (3) before the attention intervention task, and (4) after the attention intervention task. Descriptive statistics for task-specific sense of control ratings by groups are presented in Table 6.

Table 6. Means and standard deviations of task-specific sense control scores for experimental groups

Experimental Group	TSSCI-1		TSSCI-2		TSSCI-3		TSSCI-4	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
1	26.00	4.06	25.60	3.20	25.60	3.78	25.00	3.71
2	26.90	2.69	24.10	4.23	25.60	3.10	27.20	3.46
3	25.50	3.84	24.30	4.19	24.60	3.27	25.40	3.41
4	28.18	4.73	25.00	4.88	26.55	4.61	25.82	4.36
5	28.60	3.10	27.80	3.91	27.40	3.66	27.90	4.01
All participants	27.06	3.82	25.35	4.19	25.94	3.72	26.25	3.83

To look at change in task-specific sense of control over time, a 4 × 5 ANOVA (Time × Experimental Group) ANOVA was performed. As the assumption of sphericity was violated, $W(5) = .720$, $p = .012$, and because the Greenhouse-Geisser estimate ($\varepsilon = .805$) was above the recommended threshold for use of .75, Huynh-Feldt estimates were used ($\varepsilon = .927$).

Results showed that task-specific sense of control scores varied marginally over time, $F(2.78) = 2.77$, $p = .044$, $d = 0.49$. The Time × Group interaction was not significant, $F(11.12) = 0.62$, $p = .810$, $\eta_p^2 = .051$. The between-subjects factor of experimental group had no significant effect, $F(4) = 1.55$, $p = .203$.

The main effect of time was due to the significant difference between TSSCI scores at points 1 and 2, as identified by Newman-Keuls post-hoc tests ($p = .001$). Task-specific sense of control was higher for participants on average before the sense of control intervention phase ($M = 27.04$, $SD = 3.82$) than after ($M = 25.35$, $SD = 4.19$). Figure 8 shows the task-specific sense of control rating averaged across all participants and all experimental groups.

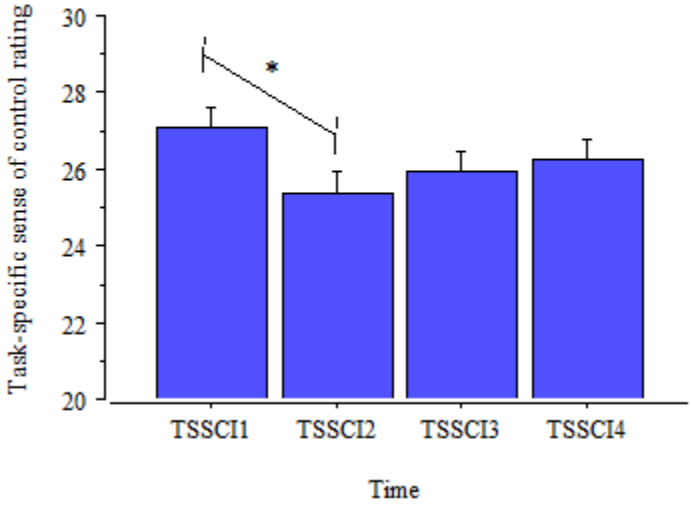


Figure 8. Task-specific sense of control ratings for all participants over time. Ratings at points 1 and 2 refer to the control intervention tasks (anagrams and concept identification cards), and ratings at points 3 and 4 refer to the attention intervention task (dot-probe task). Error bars reflect 1 SE. Asterisk indicates significant difference at $p < .05$.

The sense of control intervention had no effect on personal sense of control ratings or task-specific sense of control ratings, as the time by group interactions failed to meet statistical significance.

3.1.4. Training effects of control intervention on task performance

Task performance was measured by accuracy and reaction times in the anagram and CIC tasks (sense of control intervention) and in the ABM task (attention intervention). Within the sense of control intervention tasks, change was assessed by comparing the second and last blocks, as the first block was used for timing with the training groups before the manipulation started in the second block. Descriptive statistics for groups' performances in these tasks are given in Appendix M.

Starting the with anagram task, experimental groups did not differ from each other at the start of the task (second block) in either accuracy, $H(4) = 3.22$, $p = .522$, or reaction times, $H(4) = 3.55$, $p = .470$. Considering change over time, reaction times and accuracy were compared between the second and last blocks for each group separately to identify any training effects, or possible practice or fatigue effects. Between the second and last blocks, a decrease in accuracy was seen for Group 4, $T = 2.5$, $p = .047$, $r = -.423$. Group 2, at this stage

equivalent to Group 4, showed no significant effect, $T = 13.5$, $p = .248$, $r = -.258$. No other group showed a significant change in accuracy over the anagram task.

As for reaction times over the anagram task, no experimental group showed a significant change. Test results are shown in Appendix N.

Looking at the CIC task, experimental groups did not differ from each other in the second block in either accuracy, $H(4) = 2.02$, $p = .733$, or reaction times, $H(4) = 6.62$, $p = .157$. Between the second and last blocks, a decrease in accuracy was seen for the groups which did not receive the sense of control training: Group 2 (attention training; *Mdn* 5 to 4.5, $T = 0$, $p = .041$), Group 4 (no training; *Mdn* 5 to 4, $T = 0$, $p = .026$), and Group 5 (true controls; *Mdn* 5 to 4.5, $T = 0$, $p = .038$). The other experimental groups, Groups 1 and 3, showed no significant change in accuracy over the anagram task.

As for speed on the CIC reaction times, Group 3 (sense of control training), which had a median response time of 3014 ms in the first block and 6167 ms in the second, showed a decrease in speed over time with a large effect, T = 52, $p = .013$, $r = .558$. Group 1, at this stage equivalent to Group 3, showed no significant effect, $T = 39$, $p = .241$, $r = .262$. Group 4 showed a non-significant trend, $T = 52$, $p = .091$, for reaction times to be slower in the last block.

Only accuracy in the ABM task was analysed, as reaction time data was examined with respect to probe condition in the attention bias analyses. A 2 × 5 ANOVA (Time × Experimental Group) was performed on accuracy scores in the ABM task, comparing the first and last blocks (pre- and post-tests). Results showed there was no significant main effect of time, $F(1) = .49$, $p = .489$. There was no significant interaction between group and time, $F(1) = 1.15$, $p = .347$.

In summary, sense of control training may have improved performance as measured by accuracy in the CIC task, as seen by these groups not worsening in accuracy with increasing task difficulty as blocks continue. However, sense of control training did not consistently affect accuracy in the anagram task, or reaction times in either task, and so its efficacy is not clearly supported.

3.1.5. Training effects of control intervention on craving

Binge drinkers showed higher baseline craving for alcohol (*Mdn* = 7) than non-binge drinking controls (*Mdn* = 2), as measured on the PACS, $U = 37$, $p < .001$, $r = -.561$. Binge drinking experimental groups (Groups 1–4) did not differ from each other on PACS-measured craving, $H(3) = 1.03$, $p = .794$.

Binge drinkers and controls did not differ from each other on time-locked craving for alcohol at the start of the session (*Mdn* = 0 for both drinking groups), $U = 177.5$, $p = .417$, $r = -.114$. Binge drinking experimental groups (Groups 1–4) did not differ from each other on time-locked craving at the start of the experiment, $H(3) = 4.51$, $p = .211$. Descriptive statistics for groups' craving measures at baseline (PACS, TLC-1), after the sense of control intervention (TLC-2) and after the attention intervention (TLC-3) are presented in Table 7.

Table 7. Medians and interquartile range values for craving measures. The Penn Alcohol Craving Scale (PACS) measures past-fortnight craving, and the TLC measures time-locked craving during the experiment session.

Group	PACS		TLC-1		TLC-2		TLC-3	
	Mdn	Interquartile range	*Mdn*	Interquartile range	*Mdn*	Interquartile range	*Mdn*	Interquartile range
1	6.5	3	1	2	0	0	1	3
2	8.5	7	0	3	0	1	1	3
3	7.5	6	0	0	0	0	0	2
4	8	7	0	2	0	2	2	4
5	2	5	0	0	0	0	0	1

Results from the Friedman's ANOVA performed individually for each experimental group showed that time-locked craving ratings changed over time for Group 2, $\chi^2_F = 6.50$, $p = .039$, $r = 1.186$, and Group 4's ratings showed a trend towards a change over time, $\chi^2_F = 4.63$, $p = .099$, $r = .805$. The other three experimental groups showed no significant difference in time-locked craving ratings over the experiment.

Pairwise comparisons between Group 2's three TLC craving ratings could not statistically determine where the difference lay; therefore ratings at each point were compared against each other in a Wilcoxon's signed rank test. Group 2 showed no significant difference between ratings at points 1 and 2 ($T = 0$, $p = .317$), or between points 1 and 3 ($T = 11.5$, $p = .276$), but a difference between points 2 and 3 ($T = 15$, $p = .039$, $r = 3.35$). Time-locked craving ratings were lower at point 2 (*Mdn* = 0, interquartile range = 1) than at point 3 (*Mdn* = 1, interquartile range = 3), meaning that Group 2's reported craving increased over the attention intervention.

The weak, non-significant trend towards a difference in TLC ratings in Group 4 were likely attributable to the increase in ratings between point 2 (*Mdn* = 0) and point 3 (*Mdn* = 2), suggesting that Group 4 show a trend towards an increased craving over the attention intervention.

In summary, sense of control training (Groups 1 and 3) did not decrease time-locked craving, but may have protected against the increase in craving seen by the binge drinking experimental groups who did not receive sense of control training (Group 2, and a non-significant trend for Group 4). The finding of increased craving, or a trend in that direction, for groups not receiving control training did not extend to non-binge drinkers.

3.1.6. Experiment group intervention effect on consumption in the taste test

Motivation to drink was assessed by comparing the volume of alcoholic and non-alcoholic beverage consumed, where drinking considerably more of the alcoholic beverage is interpreted as motivation to drink. Participants who were aware of the true intent of the task ($n = 2$) were excluded from analyses, leaving a total of 31 participants who volunteered.

A 2 × 5 (Beverage × Experimental Group) was performed to examine the differences between experimental groups. There was a significant main effect of beverage, $F(1) = 4.72$, $p = .038$, $d = 0.79$, with participants overall drinking more orange juice ($M = 65.66$ g, $SD = 54.05$) than beer ($M = 53.29$ g, $SD = 60.69$). There was a significant Beverage × Group interaction, $F(4) = 2.91$, $p = .038$, $\eta_p^2 = .280$, where experimental groups drank the same amount of orange juice, but differed in the amount of beer consumed: Groups 4 and 5 drank significantly more beer (respectively $M = 81.13$, $SD = 79.22$, and $M = 91.50$, $SD = 85.52$) than Group 1 ($M = 33.25$, $SD = 22.83$; $p < .001$).

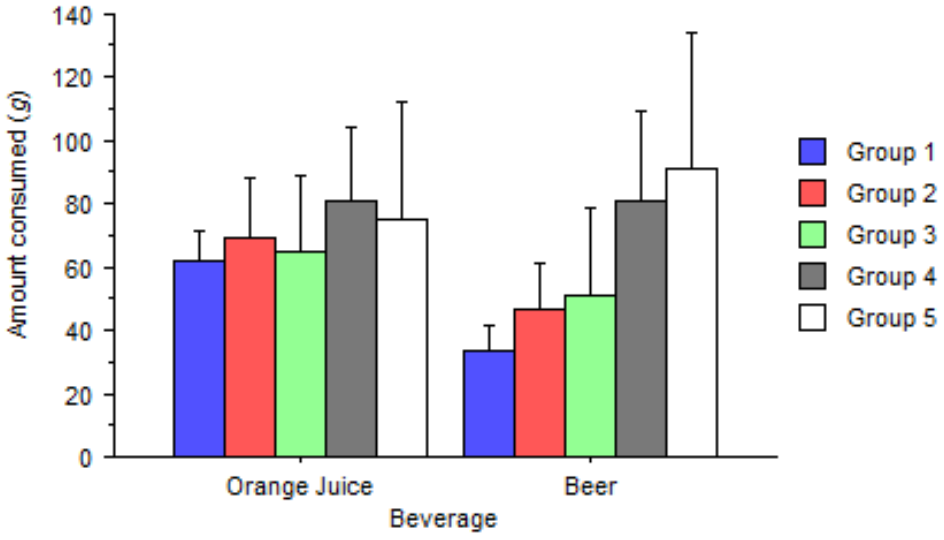


Figure 9. Amounts of alcoholic and non-alcoholic beverages consumed in the taste test by experimental group. Error bars reflect 1 SE.

3.1.7. Comparison of combined intervention against single and no interventions

Experimental groups did not differ significantly from each other on attention bias at post-test, $F(4) = 0.51$, $p = .729$, $d = .42$, and neither did the two drinking groups, $t(49) = -1.35$, $p = .182$, $d = 0.46$. No experimental group showed a significant change in attention bias, and so there is no support for a combined intervention, or for either intervention alone, in reducing attention bias.

Experimental groups did not differ on end-point craving, $H(4) = 4.43$, $p = .352$, $r = .620$. In terms of change measures, only Group 2 (attention training only) showed a significant change in craving, which was an increase over the ABM task. Group 4 (no training) showed a non-significant trend for the same. In this respect, both interventions may be better when it comes to protecting from lower craving outcomes.

Participants in Group 1 (binge drinkers who were trained in both interventions) drank significantly less of the alcoholic beverage than either Group 4 (binge drinkers who received no training) or Group 5 (binge drinkers who received no training). Both interventions were better than none.

3.2. Electrophysiological results

3.2.1. Baseline differences in attention bias between drinking groups

Baseline differences between binge drinkers and controls were analysed in an ANOVA comparing N1 peak amplitudes with drinking group (binge drinkers or non-binge drinkers) as the between-subjects factor and probe position relative to the cue (probe replaces alcohol or neutral image) as the within-subjects factor, in a 2 × 2 (Group × Probe) design. Descriptive statistics are shown in Appendix O. Results from the 2 × 2 ANOVAs are presented in Appendix P. Baseline ERPs for the two drinking groups are shown at site Pz in Figure 10 and at the FCluster in Figure 11.

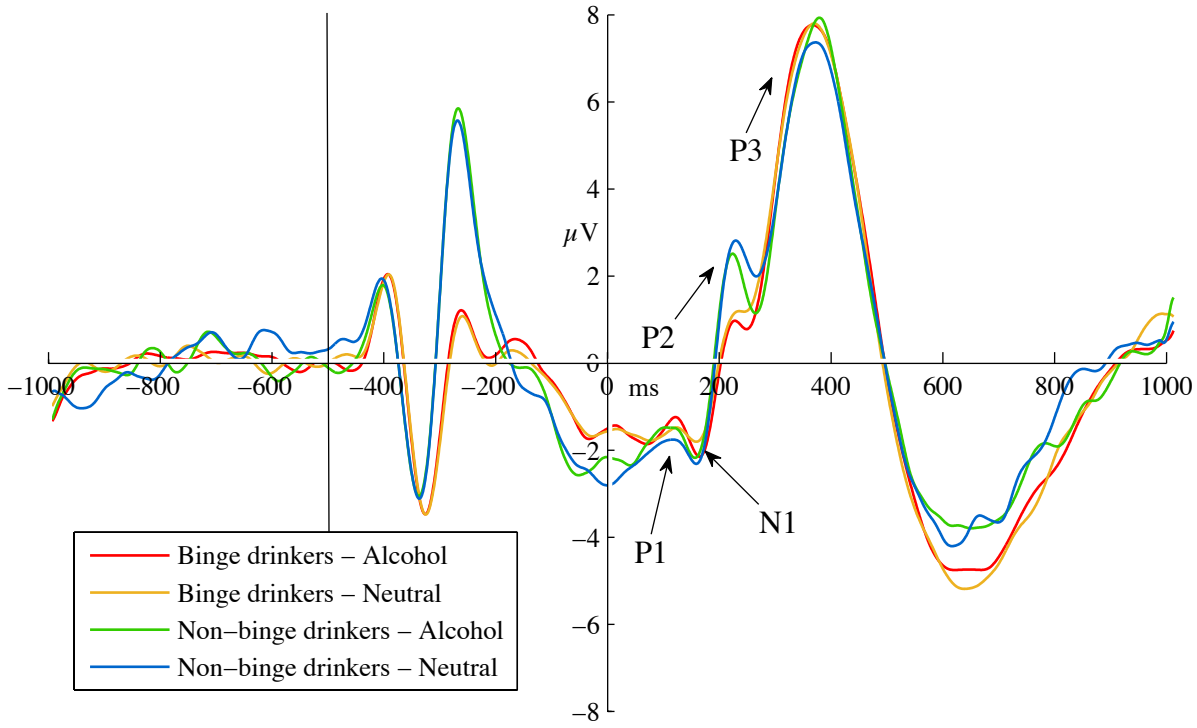


Figure 10. Pre-test ERPs at site Pz. ERPs are averaged around probes (appearing at 0 ms, and separated by probe condition: probes replacing alcohol images or probes replacing neutral images). Picture pairs appear at -500 ms.

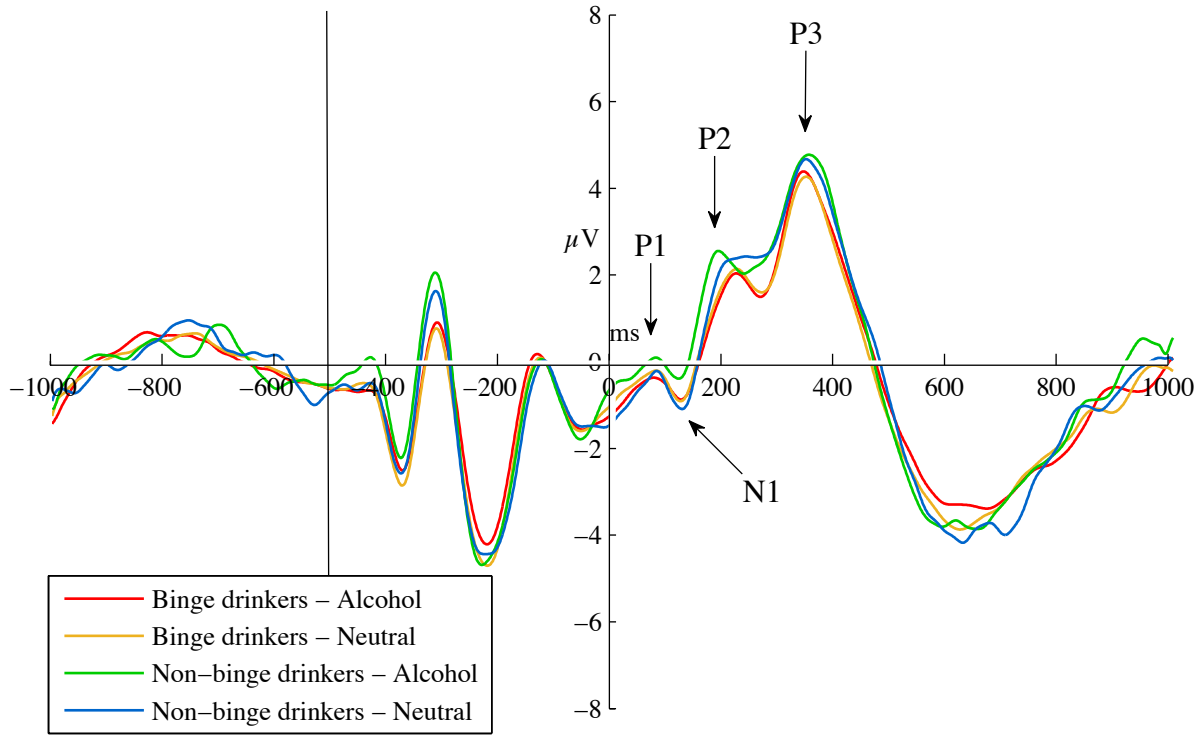


Figure 11. Pre-test ERPs at site FCluster. ERPs are averaged around probes (appearing at 0 ms, and separated by probe condition: probes replacing alcohol images or probes replacing neutral images). Picture pairs appear at -500 ms.

3.2.1.1. P1

There were no significant main effects of probe at any site and no significant interactions between probe and drinking group at any site examined. Across participants, there was a non-significant trend for P1 amplitudes at the PCluster to be larger for the neutral-probes (M = -1.13 μV, SD = 1.41) than alcohol-probes (M = -.99 μV, SD = 1.41), $F(1) = 3.09$, $p = .085$, $d = 0.25$.

3.2.1.2. N1

Parietally, at sites Pz and the PCluster, there were no main effects of probe, no interactions between probe and drinking group, and no effect of the between-subjects factor.

Frontally, there was a trend for N1 amplitudes to be greater in responses to probes replacing neutral images: At site Fz the main effect of probe was non-significant, $F(1) = 3.76$, $p = .058$, $d = 0.56$. This reflected a trend for N1 amplitudes to neutral probes to be bigger (M = -1.72 μV, SD = 2.08) than amplitudes to alcohol probes (M = -1.37 μV, SD = 2.26). There was no significant probe-group interaction, $F(1) = 1.40$, $p = .243$, $\eta_p^2 = .028$, and the between-subjects factor of group had no effect, $F(4) = 0.05$, $p = .828$, $\eta_p^2 = .001$. Similarly, at the FCluster there was a main effect of probe, $F(1) = 4.21$, $p = .046$, $d = 0.59$. Baseline N1 amplitudes at the FCluster site were larger for the neutral probes (M = -1.59 μV, SD = 1.89) than for the alcohol probes (M = -1.26 μV, SD = 2.00). There was no significant probe-group interaction, $F(1) = 1.35$, $p = .252$, $\eta_p^2 = .027$, and the between-subjects factor of group had no effect, $F(4) = 0.05$, $p = .828$, $\eta_p^2 = .001$.

3.2.1.3. P3

P3 amplitudes towards alcohol- and neutral-probes for participants on average did not differ statistically, and binge drinkers and non-binge drinkers did not differ in this regard either.

3.2.2. Training effects in Attention Bias Modification task

To look at the groups' change over the course of the task, Time (pre-test or post-test) was added as a within-subjects factor, and the factor Groups refers to the five experimental groups. Amplitudes were therefore analysed in a 5 × 2 × 2 (Group × Probe × Time) ANOVA. Significant effects were explored with post-hoc Newman-Keuls tests. Descriptive statistics are shown in Appendix O. , and results from the 5 × 2 × 2 ANOVAs are presented in Appendix Q.

Parietally, there was a main effect of time. At site Pz, P1 amplitudes were greater at pre-test (M = -0.69, SD = 1.65), than at post-test (M = -0.17, SD = 1.41), $F(1) = 10.95$, $p = .002$, $d = 0.99$. At the PCluster, P1 amplitudes were greater at pre-test (M = -1.06 μV, SD = 1.34), than at post-test (M = -0.46 μV, SD = 1.26), $F(1) = 15.36$, $p < .001$, $d = 1.20$. At these sites there were no main effects of probe or further interactions.

At sites located frontally, there were significant effects of time too on P1 amplitudes, and some Probe × Group interaction. At Fz, the main effect of time, $F(1) = 5.83$, $p = .020$, $d = 0.71$, showed P1 amplitudes at pre-test (M = 0.77 μV, SD = 1.82) were smaller than at post-test (M = 1.36 μV, SD = 1.89). This increase over time was also seen at the FCluster, $F(1) = 9.82$, $p = .003$, $d = 0.97$, where P1 amplitudes were smaller at pre-test (M = 0.59 μV, SD = 1.60) than at post-test (M = 1.30 μV, SD = 1.72).

There was a Probe × Group interaction at Fz, $F(1) = 2.95$, $p = .031$, $\eta_p^2 = .219$. This interaction came from differences in the alcohol probe condition: Group 5 had larger P1 amplitudes (M = 1.64, SD = 1.60) to alcohol probes than Group 2 (M = 0.25 μV, SD = 2.86; difference at $p = .005$) or Group 3 (M = 0.67 μV, SD = 1.11; difference at $p = .018$). The FCluster shows a non-significant trend for this interaction between probe and group, $F(1) = 2.50$, $p = .057$, $\eta_p^2 = .192$.

3.2.2.1. Changes in N1

N1 amplitudes tended to change over time, and for frontal sites this change varied depending on the probe-type, but there was no evidence of group differences.

In the parietal sites examined, there was a significant main effect of time at the PCluster, $F(1) = 5.60$, $p = .022$, $d = 0.71$. Amplitudes of the N1 component tended to decrease over time from pre-test (M = -3.19 μV, SD = 1.60) to post-test (M = -2.81 μV, SD = 1.62). This effect of time was not evident at Pz, $F(1) = 2.47$, $p = .123$, $d = 0.40$. No further main effects or interactions were seen in these areas for N1 amplitude.

In the frontal sites examined, there was a main effect of time. N1 amplitudes decreased over time at Fz, $F(1) = 4.11$, $p = .049$, $d = 0.61$, from an average peak amplitude of -1.55 μV (SD = 2.01) to -1.12 μV (SD = 1.79), and at FCluster, $F(1) = 4.58$, $p = .038$, $d = 0.64$, from an average of -1.42 μV (SD = 1.83) to -1.03 μV (SD = 1.67). At the FCluster there was a time by probe interaction, $F(1) = 4.45$, $p = .040$, $\eta_p^2 = .090$. For neutral probes, N1 amplitudes decreased over time from pre-test (M = -1.72 μV, SD = 2.08) to post-test (M = -1.01, SD = 2.00; difference at $p = .048$), but amplitudes to alcohol probes did not change over time.

A similar trend was seen at Fz that failed to reach statistical significance, $F(1) = 3.92$, $p = .054$, $\eta_p^2 = .080$.

3.2.2.2. Changes in P3

At site Pz, there was a main effect of Probe on P3 amplitudes, $F(1) = 15.27$, $p < .001$, $d = 1.16$. P3 amplitudes over pre- and post-test were greater for alcohol-probes ($M = 7.86$ μV, $SD = 2.78$) than for neutral-probes ($M = 7.69$ μV, $SD = 2.89$). This was modified by a Probe × Time × Group interaction, $F(4) = 4.06$, $p = .007$, $\eta_p^2 = .265$. This interaction is likely due to Group 4 having greater neutral-probe amplitudes in the post-test, a small change not statistically detectable using Newman-Keuls post-hoc tests. The same findings were seen at the PCluster site: there was a main effect of Probe on P3 amplitudes, $F(1) = 18.03$, $p < .001$, $d = 1.27$, modified by a Probe × Time × Group interaction, $F(4) = 3.40$, $p = .016$, $\eta_p^2 = .232$, again likely from Group 4's ERPs to neutral cues increasing from pre-test to post-test.

3.2.3. Supplementary analyses

3.2.3.1. P2 amplitude

At baseline there was a difference between binge drinkers and non-binge drinkers in the amplitude of what was identified as a P2 peak. A 2 × 2 (Probe × Drinking Group) ANOVA revealed a main effect of the between-subjects factor at parietal sites. Non-binge drinkers had markedly increased P2 amplitude to probes ($M = 3.07$ μV, $SD = 1.81$), regardless of probe type, than binge drinkers ($M = 1.63$ μV, $SD = 1.88$) at Pz, $F(1) = 4.34$, $p = .043$, $d = 0.63$. Figure 10 shows P2 amplitudes at site Pz. This difference was also seen at the PCluster, $F(1) = 4.29$, $p = .044$, $d = 0.61$, where non-binge drinkers' P2 amplitudes ($M = 0.98$, $SD = 1.60$) were greater than binge drinkers' P2 amplitudes ($M = 2.47$ μV, $SD = 1.93$). Descriptive statistics for P2 amplitudes and test statistics are presented in Appendix R.

3.2.3.2. Baseline differences in P2 amplitude between drinking groups

To investigate any differences in sense of control at baseline between binge drinkers and non-binge drinkers, independent samples t-tests were performed, with independent-samples Mann-Whitney tests for variables with heterogeneous variances.

Binge drinkers and non-binge drinking controls did not differ significantly on sense of control, as measured by the Overall subscale on the Shapiro Control Inventory, $U = 191$, $p = .739$, or on the Desire for Control subscale, $t(49) = 0.14$, $p = .886$. AUDIT and binge scores did not correlate significantly with these sense of control variables in binge drinkers

(see Appendix K.), but for the non-binge drinking participants lower AUDIT scores were associated with greater desire for control (r = -.666, p = .036).

4. DISCUSSION

4.1. Summary and discussion of major findings

4.1.1. Baseline attention bias in binge and non-binge drinkers

The current study failed to support Hypothesis 1 that binge drinkers have greater attention bias for alcohol than non-binge drinkers. Behavioural measures showed no statistical difference between the two drinking groups, although there was a statistically non-significant trend of medium effect size (p = .098, d = 0.57) for binge drinkers to have a greater focus on alcohol-related cues than non-binge drinking control participants. Neurophysiological evidence, which was expected to be a more sensitive measure, failed to show a difference between binge drinkers and non-binge drinkers: P1 and N1 amplitudes to probes replacing alcohol stimuli were predicted to be larger than those replacing neutral stimuli for binge drinkers, but amplitudes did not differ by drinking group. In fact, participants on average showed larger N1 amplitudes to neutral probes compared to alcohol probes in frontal electrodes. Additionally, P3 amplitudes were expected to be higher when probes replaced alcohol cues than neutral cues in binge drinkers as an index of cue reactivity and a marker of increased motivational salience; however binge drinkers' P3 amplitudes did not differ significantly from the P3 amplitude of non-binge drinkers.

It may be that these results reflect a reality that binge drinkers do not differ from non-binge drinkers in attention bias, and do not show the attention bias for alcohol that is seen in other drinkers. This would be in line with at least one previous study which failed to find a baseline difference between light and heavy social drinkers (Cox et al., 1999). Although raw data is rarely reported, "heavy drinkers" often have attention bias scores of at least 10 ms when stimuli are presented for 500 ms (Field & Eastwood, 2005; Field et al., 2004; Townshend & Duka, 2001), whereas binge drinkers in the current study averaged attention bias scores of 4.24 ms (4.24 ms faster to respond to probes replacing alcohol images). A binge drinking pattern may be unique in not developing an attention bias for alcohol, perhaps because of a difference in the number or length of opportunities for associative learning central to the sensitisation process (Robinson & Berridge, 1993). This, however, seems unlikely, as attention bias is directly proportional to the quantity and frequency of drug use (Field & Cox, 2008), and so binge drinkers, defined by a binge score that considers drinking

frequency and, indirectly, quantity, would be expected to show greater attention bias than non-binge drinkers. Furthermore, these results diverge from most accounts of attention bias that compare groups with less and more severe drinking patterns, including the more recent studies which use visuospatial cueing paradigms or eye-tracking as more direct measures of attention bias than the Stroop measure used by Cox et al. (1999), such as Field et al. (2004) and Townshend and Duka (2001). In particular it contradicts the finding by Petit et al. (2012) of alcohol attention bias in student binge drinkers. Their study used a long stimulus presentation time, as the current study did, in a visual oddball paradigm to reveal a difficulty disengaging from alcohol-related cues bias for the binge drinkers that was evident in ERPs but not behavioural measures.

More likely, then, is that the two drinking groups in the present study, binge drinkers and non-binge drinkers, were distinct from each other but the cognitive deficits associated with binge drinking are not fully formed in the mostly young sample that was recruited. The binge drinkers may not have engaged with the pattern for long enough to see the cognitive effects, such as attention bias deficits, that typically worsen with a continued binge pattern (Petit, Maurage, et al., 2014). In support of the idea that the binge drinkers in the present study are distinct from non-binge drinkers but show underdeveloped attention bias for alcohol are the other differences between the two drinking groups. Binge drinkers showed greater past-week alcohol craving, which is associated with attention bias in drug users (Field et al., 2009) and is a contributing factor to attention bias according to the incentive-sensitisation theory of addiction (Robinson & Berridge, 1993, 2008).

The relationships between baseline attention bias scores and drinking variables require a closer analysis. If attention bias for alcohol is expected to increase with a longer or more severe pattern of drinking, which could offer more opportunities for cue learning, a positive relationship between attention bias scores and AUDIT scores, and between attention bias scores and binge scores, might be expected. The present results showed binge drinkers' attention bias scores to be unrelated to their binge scores, and showed a negative relationship with AUDIT scores, where those with more hazardous drinking patterns were likely to have lower attention bias scores. Age also showed a negative correlation with attention bias scores. However, these correlations are not without precedent. A quadratic relationship has been reported between smoking consumption and attention bias, in which attention bias scores increase and then decrease as cigarette consumption increases in an inverted U-shaped curve (Hogarth, Mogg, Bradley, Duka, & Dickinson, 2003). Light smokers show greater attention bias than non-smokers and heavy smokers. The authors suggest that, in accordance with dual

process theories (Tiffany, 1990), attention bias for smoking cues may be present for light smokers whose consumption is governed by a goal-oriented, cognitively mediated process of substance use, while heavy smokers, despite having gone through the same process of Pavlovian conditioning, had progressed to a more automatic drug use process that operates independently of motivational processes and thus shows less attention bias. Reward dysregulation theory, while it acknowledges attention bias and the role of incentive salience as a mediator of substance use, also considers attention bias as more relevant to early stages of drug use, compared to habitual and compulsive drug use (Koob & Le Moal, 1997). A similar relationship could act for the current binge drinkers whereby with increasing duration of binge drinking, possibly although not necessarily indicated by age, and with increasing drinking pattern severity, attention bias scores may actually decrease as alcohol use relies less on the cognitively mediated processes of motivational salience and becomes more automatic. This would explain the negative correlations. On average, however, binge drinkers tended to have higher attention bias scores than non-binge drinkers, and with continued binge drinking might exhibit significantly greater attention bias than non-binge drinkers.

Apart from the proposed explanation of the recruited binge drinkers having a short history of the drinking pattern, it could also be that binge drinkers do exhibit an attention bias that this study was not able to capture, not because of an underdeveloped pattern of binge drinking but because of the measures used. The current study could not support the hypothesis of binge drinkers' relative difficulty disengaging from alcohol cues (as is tested with stimulus presentation times of 500 ms; Field & Cox, 2008), but did not examine initial attention orienting to alcohol stimuli (which can be assessed with shorter stimulus presentation times of 200 ms). Heavy drinkers have been reported to show alcohol attention bias only at longer presentation times (Field et al., 2004) and binge drinkers show ERP markers of attention bias at long presentation times (Petit, Kornreich, Dan, Verbanck, & Campanella, 2014), but perhaps this is an advanced stage that started with a bias towards alcohol in initial attention processing. This may be worth investigating in binge drinkers so that future attention retraining studies can target the appropriate bias. The stimuli themselves may have also contributed to an undetected but real attention bias: the images selected were intended to provide a variety of locally and internationally known stimuli, but if these stimuli did not relate closely to drinkers' schema of alcohol and of drinking, they may not have been recognised as salient by the binge drinkers. Personally relevant alcohol cues bias attentional processing compared to generalised stimuli, as shown in more pronounced Stroop interference effects (Wingenfeld et al., 2006). The use of personalised stimuli has been

suggested as a tool for improving training outcomes (Fadardi, Cox, & Klinger, 2006). Furthermore, the pilot group rated neutral images as more pleasant than alcohol images, which may have motivated attention shift during the 500 ms stimulus presentation time. However, effects of valence ratings (unpleasant–pleasant) on ERP measures of attentional and motivational processing are inconsistently reported at a range of ERP latencies, whereas arousal effects are more reliable, occurring at later latencies (Olofsson, Nordin, Sequeira, & Polich, 2008). The pilot group rated alcohol and neutral images as equally arousing, and study participants showed no difference in the later P3 amplitudes between image categories, regardless of their drinking status, which is where arousal effects would most likely be seen. Therefore task stimuli seem appropriate in that their valence and arousal levels are less likely to contribute to the lack of difference in attention bias between binge drinkers and non-binge drinkers.

No differences between binge drinkers and non-binge drinkers were seen in P3 amplitudes either, which did not support the hypothesis of increased cue reactivity to alcohol cues in binge drinkers (Petit et al., 2013). Again, it may be that binge drinkers had not engaged in the pattern for long enough to demonstrate effects. P3 can be a marker of heightened physiological reactivity to alcohol-related cues in individuals at risk for alcohol use disorder (Bartholow, Lust, & Tragesser, 2010). The case for reverse causation must be considered. The absence of this marker may contribute to the lack of cue reactivity and associated attention bias, rather than that their drinking was insufficient to result in increased cue reactivity as marked by P3, at this stage.

Research needed to address the limitations here should aim to confirm or challenge the existence of alcohol attention bias in binge drinkers by including participants with more established patterns of binge drinking or by considering pattern duration as a possible covariate. Previous studies have identified binge drinking-related changes over follow-ups between 9 months and 2–3 years (López-Caneda et al., 2013; Petit, Kornreich, et al., 2014), including changes to inhibitory control and other cognitive processes, and a longitudinal study would provide a stronger design to investigate whether behavioural and electrophysiological alcohol attention bias increases with a continued pattern of binge drinking. Priming drinkers with alcohol or alcohol cues may help to reveal existing biases, as cue-reactivity theory suggests drinkers may be especially vulnerable to the effects of a drug in the presence of cues that have been related historically or experientially in stimulus-response learning (Tiffany, 1990), which is one part of the incentive-sensitisation process of addiction (Robinson & Berridge, 2008). Some studies have found Stroop-measured attention

biases in heavy social drinkers only when alcohol word cues were introduced prior to testing (Cox et al., 1999), and a low dose alcohol prime can increase attention bias measured in the dot-probe task (Duka & Townshend, 2004) and approach bias measured in a visual-probe task with concurrent eye-tracking (Schoenmakers, Wiers, & Field, 2008). These modifications would allow for a stronger and more sensitive test of an alcohol attention bias in binge drinkers that navigates the present challenges of a sample with binge drinking patterns of unknown length.

4.1.2. Effect of attention training on alcohol attention bias

The current study aimed to extend the existing literature by investigating whether alcohol attention bias can be retrained through ABM in binge drinkers. The results failed to support Hypothesis 2 that ABM would reduce attention bias in binge drinkers. Attention bias scores decreased over time, meaning that less visual attention was paid to alcohol cues at post-test, but this did not vary by experimental group and so the decrease was not a result of training. Electrophysiological measures also failed to support a training effect. P1 and N1 amplitudes at parietal electrodes decreased over time, as did N1 amplitudes at frontal electrodes, but experimental group was not responsible for any of the changes.

Interestingly, there was a pattern for binge drinkers, regardless of their experimental group, to differ from non-binge drinkers in their responses over time. Binge drinkers showed a relative bias in attentional processing towards alcohol cues at pre-test, in fact, but all binge drinking groups shifted to show a relative focus on neutral cues at post-test; non-binge drinkers showed the reverse, shifting from a relative focus on neutral cues at baseline to a relative focus on alcohol cues at post-test. This could suggest a habituation to alcohol cues displayed by the binge drinkers, and could reflect a sort of sensitisation to alcohol cues in non-binge drinking controls. This is considered briefly in Section 4.2.1 with regards to the difference in P2 amplitudes between binge drinkers and non-binge drinking controls.

The minor interactions seen for ERP data are difficult to interpret meaningfully in the context of the experimental manipulations. The time-probe interaction for N1 amplitudes at the FCluster showed that only amplitudes to neutral probes decreased significantly over time. This could suggest that alcohol cues were more resistant to a habituation of attention. The group-probe interaction for P1 in the frontal sites, which showed that Group 5 had larger P1 amplitudes to alcohol probes than either Group 2 or 3, is particularly interesting. The two-way interaction suggests that training with either intervention may have lowered electrophysiological markers of attention bias enough to show a difference against the

untrained controls, but the reason for this is unclear. P3 amplitudes, reflecting cue reactivity and motivational salience, were greater towards alcohol cues, but this difference was not significantly larger in binge drinkers as might be expected. As previously discussed, a difference might be seen with participants who had a longer history of binge drinking. The three-way interaction in which Group 4 (binge drinkers with no training) showed higher P3 amplitudes to neutral-probes than to alcohol-probes in the post-test only is not clearly meaningful in the context of the experimental groups. This group showed no indication of decreased attention bias in early ERP components and so cannot be said to have decreased attention bias. Perhaps the alcohol cues simply lost their motivational salience over time. This binge drinking group was not challenged by setting performance goals and receiving reinforcement for improvement in the first intervention, and was not challenged in the second intervention when probe placement was equally likely in either position. Without any subconscious motivation that training in either intervention could have provided, the alcohol cues may have become less relevant at post-test compared to pre-test when they were novel and appetising.

In the literature there are no reports of ABM being used to train attention bias in binge drinkers, but the best point of comparison for the current study is an investigation into the generalisation of ABM training effects in heavy drinkers over a single session (Schoenmakers et al., 2007), from which the current results deviate substantially. The heavy drinkers in that study had slightly higher AUDIT scores than binge drinkers in the current study (mean score of 14.4 compared to 11.4, both above the threshold for hazardous use), and at least one binge episode in the past fortnight, but studies were otherwise similar. The heavy drinkers' attention bias scores were similar to those of the current binge drinkers, and training conditions were similar between the studies: training used 30 image pairs (compared with 40 in the current study) presented for 500 ms over 576 critical trails (compared with 600). The authors' report of a training effect may have relied on the use of a priming dose of alcohol for all participants, which can increase the chance of finding an attention bias in heavy drinkers (Duka & Townshend, 2004; B. T. Jones & Schulze, 2000).

The low baseline attention bias scores for binge drinkers in the current study could have made it difficult to detect changes over time, especially when training effects for ABM on appetitive biases, when seen, are typically small (Beard et al., 2012). This may result from differences in the neural mechanisms governing appetitive versus threatening or aversive biases that make them more resistant to change (Field, Mogg, & Bradley, 2006). Any effects of training may have been too small to detect as group differences in the current sample,

either behaviourally or electrophysiologically. Limited by the lack of baseline attention bias, these findings are also restricted to the conditions of the visual probe task used: picture stimuli presented at 500 ms in a top-bottom formation for five blocks of 120 training trials in a single session. However, there is support for each of these training elements. Stimulus type is unlikely to have interrupted an existing training effect as although words have been reported to generate larger training effects in emotional disorders (Hakamata et al., 2010), a review including appetitive biases that considered the comparison group in more detail showed that this factor only moderates attention bias when two active training conditions are used (e.g., train-towards and train-away from alcohol), in which case picture stimuli are associated with stronger effects (Beard et al., 2012). The top-bottom orientation of stimuli tends to be the most effective (Beard et al., 2012; Hakamata et al., 2010). There is mixed evidence from meta-analytic reviews as to whether the number of trials or sessions is a moderator of training effects, with some suggesting so (Beard et al., 2012; Hakamata et al., 2010) and others challenging this (Hallion & Ruscio, 2011; Mogoaşe et al., 2014), but single sessions can produce training effects (Schoenmakers et al., 2007). The present study may fall short particularly when compared to past studies' training effects when two active controls were used (e.g., train-towards and train-away in Field et al., 2007; Field & Eastwood, 2005) because such a watershed design increases the chances of finding an effect (Beard et al., 2012; Hallion & Ruscio, 2011), but the more clinically relevant use of an untrained control group can also show effects of training (Schoenmakers et al., 2007). Thus there is strong justification for the training measures used, although future research should re-examine these parameters with a group of binge drinkers with more severe alcohol attention bias and could track effects with an increasing number of sessions to gauge a required number for meaningful and sustained change.

Consideration should also be given to alternative training methods. Similar in nature to attention bias, is the automatic approach of appetitive drug-related cues, called *approach bias*. Approach bias is accounted for in incentive sensitisation models (Robinson & Berridge, 1993; Stewart, de Wit, & Eikelboom, 1984), but is seen as a result of the attribution of incentive salience. Incentive salience may contribute to approach bias by making drug-related cues more attractive and wanted, in addition to the conditioned learning processes that can encourage the approach of drug-related stimuli and environments. Like attention bias, approach bias can be manipulated to discourage automatic cue approach. For example, it can retrain approach bias for alcohol in hazardous drinkers with generalisation to new stimuli and other stimuli types (Wiers, Rinck, Kordts, Houben, & Strack, 2010), and has successfully

been used with dependent drinkers to decrease relapse rates at one year post-treatment (Eberl et al., 2013). Modification of approach bias involves inducing an avoidance response in a task similar to the visual dot-probe used for ABM. Participants are trained to respond to alcohol-related stimuli by using a joystick to pull away, and to approach alternative cues, such as soft drinks. Approach and avoidance responses are sometimes emphasised by causing the picture size to increase (approach) or decrease (avoid). While training approach bias relies on the same understanding of drug cues developing increased incentive salience with repeated administration (Robinson & Berridge, 1993), inducing an avoidance response in this way may have a more dramatic effect than the subtle priming of visual attention in ABM. It would be interesting to compare the two training methods in binge drinkers, looking at outcomes of alcohol craving and alcohol attention.

4.1.3. Effect of sense of control training on personal and task-specific sense of control

Given previous reports of sense of control training increasing task-specific sense of control in moderate drinkers (Shamloo & Cox, 2014), sense of control training was expected to increase task-specific sense of control in binge drinkers (Hypothesis 3), but this was not supported. Task-specific sense of control decreased for participants in general after completing the anagram and CIC tasks in the Control intervention phase, but the experimental manipulation had no effect, meaning that sense of control training did not improve task-specific sense of control, which is not consistent with previous findings by Shamloo and Cox (2014). In an extension of the author's original findings that sense of control training can increase task-specific sense of control (Shamloo & Cox, 2014), changes to personal sense of control were investigated, with an increase expected for binge drinkers receiving training. This hypothesis was not supported: personal sense of control scores did not change significantly over time and did not vary by group.

That the expected effects of increased task-specific sense of control, which were not found, did not extend to personal sense of control is not necessarily a problem. While it might be desirable to address the low personal sense of control reported in heavier drinkers, the effect on task-specific sense of control is still a valuable goal in that increasing sense of control over a task could improve effort on that task. Should that task be a training task, such as the dot-probe paradigm used for ABM, increasing task-specific sense of control may be a valuable tool for improving participants' performance and thus increasing possible training effects. Accordingly, the ability of sense of control training to increase task-specific sense of

control requires special attention in future efforts to replicate the findings of Shamloo and Cox (2014).

The lack of support for an increase in sense of control with training suggests an mechanism other than increasing sense of control is responsible for the other benefits of the control intervention, such as protective effects against worsened task performance and increased craving, as discussed in Sections 4.1.4 and 4.1.5. However, other challenges to the delivery of the intervention in particular are likely responsible for this result of no effect on sense of control reports. Task difficulty may have posed a challenge to the manipulation delivery, and have been responsible for the decrease in task-specific sense of control ratings after the first intervention: performance data showed that accuracy during the anagram and CIC tasks tended to worsen or stabilise, but not improve as expected. This would make it hard to encourage feelings of success thought to underlie the increase in sense of control shown previously (Shamloo & Cox, 2014). Measurement differences between the current study and the original could also mean that the studies measured different aspects of sense of control, or that the current study was unable to detect real changes to sense of control experienced by those who received the intervention. Shamloo and Cox (2014) reported developing a measure using the Positive, Negative, and Overall scales of the Shapiro Control Inventory, which the current study replicated but using a refined number of items given its use as a repeated measure (three times as the personal sense of control measure and four times as the task-specific sense of control measure). Although efforts were made to validate its similarity to the full-item subscale, this may not measure sense of control in the same way. Furthermore, the authors' description of the Overall Sense of Control subscale better describes the Domain-specific subscale, and their confusion over terms points to likely difference between the studies. Including domain-specific sense of control, as it is described in the Shapiro Control Inventory, would be an advantage for future studies as alcohol-related changes might be expected in domains of the body and over substance use (Surgenor et al., 2006), but this subscale should be analysed separately from the "Overall" subscale (a combination of Positive and reverse-coded Negative items).

The lack of significant baseline differences in sense of control on baseline measures between binge drinkers and non-binge drinkers as measured by the Shapiro Control Inventory helps to rule out the possibility that any changes in sense of control were due to baseline differences and not the training, but also indicates that the control intervention was attempting to increase sense of control in a group that was not deficient in the first place. The sense of control training might be more effective with a sample of binge drinkers with a more

established drinking pattern, who would be expected to show lower sense of control, as low sense of control is associated with higher alcohol consumption (Shamloo & Cox, 2010). Another alternative would be to measure control over drinking behaviours specifically as this is a key predictor of binge drinking frequency along with positive control beliefs (feelings about factors or situations that would facilitate binge drinking; Norman, Bennett, & Lewis, 1998). Binge drinkers may show a deficit that is specific to alcohol, as this research suggests, or even a deficit that is situational or triggered by drinking itself, and thus was not detected in the laboratory setting.

Future research attempting to replicate the training effects should include a manipulation check to confirm whether the manipulation is being delivered effectively. Automated feedback accompanying the computerised tasks could make the training more effective by avoiding any unintended performance pressure that may be introduced with having an experimenter monitor performance, and could further standardise the sense of control training delivery. This could easily be incorporated into an experimenter-blind design, too.

4.1.4. Effect of control intervention on task performance

The current study provided mixed support for Hypothesis 4 that sense of control training would improve task performance by increasing speed and accuracy. Reaction times showed no change in the anagram task. In the CIC task, there was no support for the hypothesis that sense of control training could decrease reaction times: Group 3, who received training, actually showed increased reaction times and the untrained Group 4 showed a non-significant trend to do the same. Accuracy in the anagram task and the later ABM task was not improved. There was some support for the beneficial effect of sense of control training on accuracy in the CIC task: accuracy decreased for all groups not receiving the sense of control intervention. Shamloo and Cox (2014) did not measure reaction times but the current study replicates their finding that sense of control training improved accuracy in the concept identification card task only.

The Shamloo and Cox (2014) study aimed to test the effectiveness of a novel intervention, a combination of tasks and manipulations for which there is substantial evidence of their effectiveness in increasing sense of control: providing choice (e.g., Surrette & Harlowe, 1992), giving participants information about the tasks (Skinner, 1996), setting specific and challenging but achievable goals (Gauggel, Hoop, & Werner, 2002; Locke & Latham, 1990), and delivering positive feedback contingent on performance (Elliot et al.,

2000). Changes in performance are best understood as caused by these intervention elements – the relative contribution of each intervention element is unknown, and worth investigation to keep the manipulation focussed and efficient – but effects in the current study were limited to certain tasks and measures.

The training effects did not extend to reaction times or to accuracy in the anagram task. Shamloo and Cox (2014) did not record reaction times, but in the current study reaction times were expected to decrease with training as a marker of more efficient and successful performance. Reaction times in the CIC task increased for one trained group (Group 3) and for one untrained group (Group 4). The unexpected slowing of responses in a group receiving sense of control training could still be a result of the intervention. A choice over tasks can increase commitment to that task (Surrette & Harlowe, 1992), for example, and so increased sense of control could increase reaction times by encouraging persistence. This may have given time for more accuracy in the CIC task affected by sense of control training. Heavy social drinkers are less likely to have a persistent quality to their personality (Townshend & Duka, 2001) and so training might have addressed a deficit here. However, the fact that this was not seen in the trained Group 1 shows this effect to be weak and inconsistent. That the finding of improved or protected accuracy is restricted to the CIC task may be attributable to the relative difficulty of the anagram task, which was reflected in lower overall accuracy scores compared to the CIC task. This may have made it harder to encourage the feelings of success assumed to underlie these intervention techniques (Shamloo & Cox, 2014) and could have contributed to the decrease in task-specific sense of control ratings reported by all participants.

These findings indicate that sense of control interventions can be delivered over simple problem-solving tasks to improve accuracy, provided the tasks are at an appropriate difficulty level. Future research should explore a wider range of tasks for intervention delivery. If blocks of the tasks are not designed to be increasingly challenging, accuracy and reaction time could serve as manipulation checks for time-goal setting and achievement, to test whether the intervention is being delivered appropriately, and which tasks are most conducive to intervention delivery. Future research may wish to expand on the Shamloo and Cox (2014) study by using tasks better suited for highlighting feeling of success and thoughts of the self as efficacious and the environment as responsive, or by tailoring tasks, such as difficulty level in the anagram task, to the individual. Applied to problem-solving tasks and placed beforehand, sense of control training was not able to improve accuracy on a subsequent task (ABM), but applying the intervention techniques (e.g., choice of picture

stimuli sets or order, feedback and goal-setting) directly to the dot-probe task may improve the effect of attention retraining, and warrants further study. Computerising intervention elements would again offer the benefit of standardised delivery, which could improve the stability of the effect size and allow for observations about the relative contribution of each intervention element.

4.1.5. Effect of control intervention on craving

There was no direct support for Hypothesis 5 that sense of control training decreases craving, as was reported by Shamloo and Cox (2014), because participants who received sense of control training showed no change in craving. However, over the course of the ABM task, that is, after the control intervention, untrained binge drinking groups showed an increase in craving (Group 2) or a non-significant trend (Group 4) for increased alcohol craving. Therefore, sense of control training may have protected against an increase in craving in a subsequent task (ABM).

Of the two binge drinking groups who did not receive sense of control training, only Group 2's increase was statistically significant. Since the difference between Groups 2 and 4 was the attention intervention, it could be argued that these results reflect ego depletion: the exertion of training in the ABM task without the protective effects of sense of control training beforehand (Group 2) resulted in an increase in reported craving (the challenge to self-control). It has been reported that ego depletion is only seen in college-age samples (Dahm et al., 2011), and so this could describe the current study but be of limited further use to a generalised population. However, in the face of strong criticisms of the ego depletion effect (Carter, Kofler, Forster, & McCullough, 2015; Xu et al., 2014), an alternative explanation seems more likely. A cognitive challenge (the difficult anagram and CIC tasks) without the support of the sense of control training, such as positive reinforcement and reminders to stay relaxed for best performance, could have activated automatic action schema that promote craving and drug seeking (Tiffany, 1990). Internal stimuli, such as a frustrated mood, or physical states, such as fatigue, could trigger a learned drug-use action plan, especially when confronted with stimuli associated with alcohol in the ABM task. This would also explain why the non-binge drinking controls who did not receive sense of control training either (Group 5) did not report an increase in craving at the same time, because they have not developed the same learned action schemata through excessive drinking. The increase in craving over the ABM task reported by some binge drinkers deserves further attention. It may be that the cognitive challenge of the previous tasks allowed the picture stimuli to elicit this

response, in which case future ABM sessions, especially with at-risk populations, should take care to consider what demands are placed on participants before training sessions and to investigate more appropriate tasks than the anagrams, say, over which to deliver the intervention to avoid increasing craving.

Interpretations are limited by the use of a single-item time-locked craving assessment. This measure has previously proved useful for detecting transient changes that longer-form questionnaires miss (e.g., Field & Eastwood, 2005), but may not capture other aspects of craving where binge drinkers are known to differ. While incentive-sensitisation models of addiction predict drug seeking to be related to craving, drinking patterns may differ on the strength of this relation in practice. For example, binge drinkers tend to have high drink refusal self-efficacy compared to other patterns (Oei & Morawska, 2004), and so "craving" may not be as strongly related to drug seeking. The *ad libitum* taste test is a good complement to the question of craving and its relation to drinking behaviour. In summary, while sense of control training did not decrease craving, there is some support for the notion that sense of control training can protect participants against otherwise induced craving.

4.1.6. Effect of interventions on alcohol consumption

Experimental groups did not differ on the amount of orange juice consumed in the taste test, but groups receiving neither sense of control training nor attention training drank significantly more beer than the group receiving both types of training. Hypothesis 6 that binge drinkers given one of the interventions would consume less alcohol was not supported. The combined intervention, on the other hand, did show a significant reduction in alcohol consumed when compared with untrained participants.

The unexpected increase in consumption by untrained participants can be accounted for with a cognitive model of drug urges. Untrained binge drinkers (Group 4) may have experienced the frustration of the difficult anagram and CIC tasks that activated an automatic action schema (Tiffany, 1990) which involved increased motivation to drink (and the non-significant trend of increased craving in Group 4). Without the attention bias retraining discouraging a focus on the alcoholic beverage, these participants could have consumed more beer. However, it is interesting that non-binge drinkers who received no training (Group 5) also consumed more alcohol than binge drinkers receiving both trainings (Group 1). This could point to binge drinkers and non-binge drinkers being more similar in motivation to consume alcohol than anticipated, possibly a relic of a sample of "underdeveloped" binge drinkers, or could suggest a different mechanism acting in non-binge drinkers. Pleasantness

ratings are significant predictors of performance in the taste test (A. Jones et al., 2015), and it may be that for non-binge drinkers who chose to participate the alcoholic drank was experienced as pleasant, and thus more was consumed, while the alcoholic beverage may have been less pleasant for binge drinkers, perhaps because compared against more established preferences. Alternatively, as non-binge drinkers are more conscientious than non-binge drinkers (Ichiyama & Kruse, 1998), a trait which is described by deliberation and fastidiousness or scrupulousness (Costa & McCrae, 1985), they may have wanted to perform carefully in the taste test, particularly in regard to the alcoholic drink, the taste profile of which they might be less familiar with through less experience (what is a "bitter" beer, etc.), and thus they consumed more alcohol but not more orange juice.

The taste test was made voluntary on ethical grounds as the current study concerns an at-risk drinking group. Of those participants who chose not to complete the taste test, most cited having to drive on a restricted driver's licence after the experiment (which does not allow for a blood alcohol content over zero in New Zealand) and one participant cited an allergy as reasons for non-participation. This reduced the statistical power of the associated analyses and introduces the possibility that non-participators differ systematically from participants who did complete the taste test. For example, they may have been younger which was associated with higher behavioural attention bias, or they may have been more conscientious. Future researchers should advertise participation in a study that "may involving sampling alcohol" (e.g., Marlatt et al., 1973) to improve power, but should bear in mind that this qualification to participation may result in a sample of a certain type of binge drinker, such as more uninhibited binge drinkers and fewer binge drinkers from the constrained segment (drinkers who limit consumption because of other responsibilities; McMillen et al., 2004).

4.1.7. Benefit of combined intervention

Hypotheses 1, 5, and 6 predict that the binge drinkers given the combined intervention would fare better on the respective outcomes of alcohol attention bias, alcohol craving and alcohol consumption than the binge drinkers given just one of the interventions. No intervention showed an advantage in decreasing attention bias scores. The sense of control training did not have immediate effects at the time of the manipulation delivery, but may have had a slight protective effect against the trend towards increased craving over the ABM task that was seen by binge drinkers who did not receive sense of control training. The combined intervention had the advantage over the interventions presented singly in the case

of motivation to drink: binge drinking participants receiving both training interventions consumed less beer than binge drinking and non-binge drinking participants who received no training. The hypothesis of the combined intervention's superiority when compared against just one intervention or no interventions was partially supported.

Sense of control training was investigated in the present study as a possible adjunct treatment to Attention Bias Modification. It was thought that it could address a shortcoming of the attention training by increasing sense of control, as well as making attention training more effective by improving accuracy in the ABM task. With a possible trend to protect participants from increases in craving during the experimental session and limited effects on accuracy in the ABM task, there is modest support for a combined intervention placed in this order. However, in the absence of concomitant increases in task-specific or personal sense of control, the utility of these effects must be questioned. Placed beforehand, sense of control training was not able to improve accuracy on a subsequent task (ABM) once training was removed, but applying the intervention techniques (e.g., choice of picture stimuli sets or order, feedback and goal-setting) directly to the dot-probe task may improve the effect of attention retraining.

The advantage of the combined intervention in decreasing alcohol consumption is particularly noteworthy. The contribution of the control intervention was its protective effect on craving, which meant that exposure to the alcohol cues did not increase craving as it did for other participants. Craving motivates cue approach which may have been responsible for untrained participants' greater consumption levels. It is interesting to note that while attention bias training showed no effects in the behavioural or ERP data, it acts in some way to reduce motivation to drink. This suggests that attention bias modification may rely on more than just manipulating attentional processes, or that the effect of the two interventions together is more than just additive, and that there might be interaction between various behavioural, attentional, and motivational processes.

4.2. Summary and discussion of supplementary findings

4.2.1. P2 amplitude difference between binge and non-binge drinkers

Non-binge drinking controls showed higher P2 amplitudes after probe-presentation than binge drinkers, which was not predicted, although P2 is sensitive to automatic attention capture just as the early (N1, P1) components are (Carretié, Hinojosa, Martín-Loeches, Mercado, & Tapia, 2004). P2 is also enhanced for motivationally relevant stimuli including

drug-related stimuli (Littel & Franken, 2012). In the ABM task, every trial presents an alcohol-related cue and a neutral cue simultaneously and so it is not possible to determine if one image category was responsible for the P2 peak in non-binge drinkers. Additionally, it would be difficult to interpret the non-binge drinkers' evaluations of those cues on the basis of this ERP component. Unpleasant images elicit larger P2 amplitudes than similarly arousing pleasant images (Carretié, Martín-Loeches, Hinojosa, & Mercado, 2001; Carretié, Mercado, Tapia, & Hinojosa, 2001; Delplanque, Lavoie, Hot, Silvert, & Sequeira, 2004; Olofsson & Polich, 2007), and are sometimes interpreted as revealing a *negativity bias* in early attentional processing, but there is evidence that P2 is sensitive to both positively and negatively valenced information (Carretié et al., 2004). It might be interesting to further investigate whether binge and non-binge drinkers differ in regard to the processing of drug-related images, on the basis of their being less motivationally relevant to non-binge drinkers than binge drinkers, as this may indicate the relative usefulness of stimuli valenced in a certain direction for ABM training specific to binge drinkers.

Changes in P2 amplitudes can also be considered in light of binge drinkers' and non-binge drinkers' different patterns in attention bias scores over time. Binge drinkers, regardless of experimental group, shifted from a relative focus on alcohol cues at pre-test to a relative focus on neutral cues at post-test, while non-binge drinkers did the reverse. This could be read as binge drinkers experiencing a habituation over time where the initial salience of alcohol-related cues wore off, while non-binge drinkers experienced a sort of sensitisation to alcohol cues. Since non-binge drinkers showed heightened P2 amplitudes, reflecting increased emotional processing, it may be that non-binge drinkers initially are drawn to the neutral cues because they are processed as pleasant or otherwise attractive, but experience a habituation over time and shift their attention to focus relatively more on alcohol cues which previously had not commanded as much visual attention and thus were novel. Alternatively, if the heightened P2 reflects a negativity bias rather than a positive reaction, the non-binge drinkers may have showed a relative focus on neutral cues initially in response to an aversive reaction to alcohol cues at pre-test, but through exposure experienced a desensitisation to the aversive reaction (rather than a habituation of a positive processing of neutral cues) at pre-test, and thus came to show a focus on the relatively novel alcohol cues at post-test. The task design, which presents an alcohol-related and a neutral cue on every trial, allows only for speculation on this count.

4.3. General limitations

4.3.1. Design and internal validity

Findings are liable to order effects as this study tested two interventions without counterbalancing. In addition to avoiding the loss of statistical power that would have been incurred otherwise, the decision not to counterbalance the intervention order was motivated by a hypothesised benefit for the combined group. Placing the sense of control training first was predicted to improve outcomes by improving task accuracy and thus training efficiency on the attention training that followed. However, this introduces the possibility of a type of practice effect. For example, participants may have become more comfortable with the researcher and procedures over time, resulting in an increased willingness to disclose accurate ratings later. This could be responsible for the increase in craving for some binge drinkers after the ABM, rather than cue exposure itself inducing craving. Fatigue or boredom, expected to increase over the course of the experiment, could also affect results. Participants might be less willing to set challenging goals in the second task of the Control intervention, for example. Order effects could be assessed by a counterbalanced design in future, or avoided by applying the sense of control training directly to the attention training. This would involve delivering the intervention elements during the ABM task. Choice could be a choice of stimuli set; information enhancement could remind participants with on-screen prompts to centre their attention on the fixation cross for more accurate responding, or to stay calm to improve performance; goal-setting could be facilitated by showing accuracy percentages and mean reaction times after task blocks; and contingent positive feedback could involve visual or auditory reinforcing stimuli. Reinforcement could also be achieved through the application of game-design elements (*gamification*), such as scoring and the ability to unlock rewards or game levels. Gamification of the ABM task in a mobile application has been successful in retraining threat attention bias in anxious individuals (Dennis & O'Toole, 2014).

Possible experimenter effects include inconsistent implementation or implementation mediated by positive or negative interactions with the participants, as well as unconscious personal biases of the experimenter, who was not blind to experiment conditions out of necessity. For example, the experimenter may have been warmer or used more socially reinforcing language towards participants in the combined intervention groups which motivated them to try hard and achieve goals in the sense of control training tasks as a

socially desirable response and not as an effect of the manipulation elements of positive reinforcement and so on. It should be noted that efforts were made to avoid this by standardising testing sessions where possible, for example, with the use of an experimental script. Gamification again would offer a way to standardise intervention delivery. A selection bias may have also acted. The compensation on offer for participants' time worked out to be less than a minimum wage rate and so may have attracted the large numbers of students, despite efforts to recruit outside this demographic. Participants selected in this way may differ systematically from a truly random selection of binge drinkers, for instance, in related demographic variables, or a personality factor such as agreeableness which could have facilitated the experimenter's delivery of the sense of control training manipulations.

4.3.2. External validity and generalisability

The representativeness of the current sample of binge drinkers is a critical issue that affects the findings on measures of alcohol bias, craving, and consumption. The McMillen et al. (2004) report of drinking behaviours in New Zealand, commissioned by what is now the Health Promotion Agency, offered a challenge to the perception of binge drinking as a youth issue that typically affects males of lower income. The study showed binge drinking to be at least as common among middle-aged Pakeha (New Zealand Europeans), and just as prevalent among women. Considerable effort was made in the present study to recruit participants up to age 50 and to advertise extensively outside the university to reflect this varied demographic. However, the recruited sample of binge drinkers comprised mostly young university students who might better represent the stereotype than the average binge drinker. New Zealand binge drinkers are most likely to be full-time wage or salary earners, and uninhibited binge drinkers (a segment comprising 29% of all adults) are most likely to have above average incomes (McMillen et al., 2004). The socioeconomic profile of students might be expected to fall outside these descriptors and thus does not offer them the same level of disposable income that is seen to be a factor in older adults' binge drinking (Hodges & Maskill, 2014). Time is another resource that may affect the current sample's binge drinking pattern. Binge scores of students may classify them as binge drinkers, as seen in the current study, perhaps because New Zealand students drink more hazardously than their non-students peers (Kypri, Cronin, & Wright, 2005), and their more hazardous drinking occasions are enough to boost binge scores into the classification range of binge drinker. However, students' binge drinking can also be defined by interrupted patterns of seasonal drinking, characterised by high consumption early in the academic year and after major assessments and low consumption

during study and exam periods, which may affect the development of deficits traditionally seen with extended binge drinking patterns. Elsewhere, student binge drinkers have shown alcohol attention bias in ERP measures (Petit et al., 2012), with evidence of worsening over time (Petit, Kornreich, et al., 2014), so student populations may not be entirely unsuitable, but the length of time engaging in the binge pattern should be considered as a possible moderator of changes to attentional processes. This could provide a particular challenge to future research, in addition to existing definitional difficulties, when binge drinking is defined in part by irregular or episodic consumption in the first place.

These differences between the recruited binge drinkers and "typical" binge drinkers are important because they can explain many of the unexpected findings, such as attention bias for alcohol not being higher for the binge drinkers or binge drinkers not showing differences in sense of control at baseline as measured with the Shapiro Control Inventory. Critically, these differences could affect the generalisability of the findings to other binge drinkers. These interventions could be more or less effective with more representative binge drinkers or other drinking groups. Other questions of generalizability concern whether the interventions delivered would translate well outside a laboratory setting to a clinic or a home. Similarly, the current study cannot speak to generalisability across time, and these issues need to be considered in more robust designs if the interventions' efficacy can first be established with a group of representative binge drinkers.

4.3.3. Analyses and statistical power

Despite large numbers of eligible participants showing interest, few committed to the study. The final sample was smaller than desired and was likely underpowered to detect anything but substantial effect sizes. Frequent and infrequent binge drinkers are less conscientious than non-binge drinkers (Ichiyama & Kruse, 1998), which may account for this poor "follow-through" of interested, eligible binge drinkers in enrolling in the study, although specific reasons for their unwillingness to sign up are not known. The pilot groups used for validation of the abridged repeated measure of sense of control and the stimuli sets for the ABM task were also small, and those analyses also underpowered. Increasing the sample size will provide a better estimate of possible training effects.

Newman-Keuls post-hoc tests were used as appropriate tests for situations where even small differences are important to find (McHugh, 2011). While associated with an increased risk of making a Type I error (a "false positive"), the test is ranked as halfway between conservative and liberal in a comparison of post-hoc tests by Huck, Cormier, and Bounds

(1974). Newman-Keuls post-hoc tests were appropriate in this study given that effects were expected to be small, such as attention bias for alcohol, which has previously been detectable only at the neurophysiological level, or ABM training effects, which are typically small for appetitive bias when they exist (Beard et al., 2012). Furthermore, the critical multiple comparisons were planned, meaning that in effect only a subset of the possible comparisons were conducted.

4.3.4. Measurement

The AUQ-derived binge score using the cut-off scores recommended by Townshend and Duka (2002) may be insufficient to accurately classify binge drinkers cross-culturally, or may include too many participants with poorly established patterns of binge drinking that resemble light or non-binge drinkers in some cognitive effects. A cognitive model of binge drinking suggests that binge drinkers can be distinguished from light/social drinkers by their alcohol outcomes expectancies, and from dependent drinkers by their drinking refusal self-efficacy (Oei & Morawska, 2004). This suggests a practical way of checking sample classification. Duration of drinking pattern could also be considered, along with other distinctions such as frequency (e.g., Ichiyama & Kruse, 1998).

Although piloted with a small group of young student drinkers, the measure of sense of control used in the current study has many unknown qualities, such as how well it operationalises the construct of personal and task-specific sense of control beyond its reliability with the Shapiro Control Inventory items on which it was based. This may be responsible for the finding of the sense of control training being unable to affect either personal or task-specific sense of control, a finding which was discordant with previous research (Shamloo, 2007, as cited in Fadardi et al., 2011; Shamloo & Cox, 2014)

4.4. General implications

4.4.1. Theoretical

Central to most theories of addiction is the concept of loss of control over casual drug use in the transition to habitual, automatic, or compulsive use and addiction. Attempts to increase personal sense of control by way of task-specific sense of control may be too far removed from the specific loss of control over drug use that addiction theories consider. If delivered over more suitable tasks, such as the ABM task which is more closely associated with drug use behaviours, and if delivered to binge drinkers who show more established

deficits in sense of control and heightened alcohol craving, these interventions may be more effective.

Prominent addiction theories tend to recognise the role of sensitisation, but ascribe varying degrees of importance to it. In incentive-sensitisation theory, the attribution of motivational salience is what leads to attentional bias for drug-related cues. If it is taken that binge drinkers in the current study had, on average, a relatively unestablished or interrupted pattern of binge drinking, which could be related to their profile as largely young, student drinkers, then the absence of attention bias in this group can be accounted for by each of these theories. Incentive-sensitisation theory would suggest that binge drinkers' sensitisation to alcohol is too underdeveloped for motivational salience to have been reliably attributed to alcohol-related cues, but that this could change with continued drug administration. While craving is associated with attention bias, this relationship is not as strong for alcohol as it is for caffeine and illicit drugs (Field et al., 2009), and so the finding of binge drinkers' increased craving but not attention bias for alcohol when compared with non-binge drinkers is plausible at an early stage of drinking development. Ignoring motivation, habit learning theory would submit that the pairing of alcohol-related cues with the effects of alcohol was too weak to develop attention bias. In both these cases, it may also be that the cues used in assessment were inappropriate to elicit an existing attention bias, perhaps because the stimuli presented were not similar enough to cues binge drinking participants' find motivationally relevant or because stimuli were too far removed from alcohol cues in participants' learned experience. As reward dysregulation theory sees sensitisation to be more important to the early stages of vulnerability to drug use, binge drinking participants' intoxication and withdrawal processes could still be in homeostasis. It might take a greater frequency or severity of binge drinking to disrupt the regulation of reward processes. As the theories of addiction discussed are not mutually exclusive but can be read as emphasising different mechanisms in the transition to uncontrolled use (Everitt et al., 2008), the present findings can be considered in light of each. Future research may be interested in comparing these theories addiction in their ability to account for different stages or levels of severity of binge drinking by investigating the underlying neural mechanisms and associated neural networks.

4.4.2. Research

This study shows that individuals classified as binge drinkers using measures well cited in the literature do not necessarily exhibit features associated with increased consumption such as greater alcohol attention bias scores in comparison to non-binge drinkers. A greater

spectrum of binge drinkers may exist, and researchers should be wary of what may be a catch-all term, which is defined and applied chaotically in the scientific literature as is (Herring et al., 2008).

Binge drinking warrants attention as each binge episode poses the risk of acute harm (Babor et al., 2010) and the negative effects increase with the frequency of binge drinking (Wechsler et al., 1994). However, the societal concern is in danger of being blindsided by this term. For example, concern coming from political and journalistic corners in particular centres on youth culture (Fox, 2015; Measham, 2008), and plays into stereotypes of binge drinking as only a youth issue when public health research indicates otherwise (McMillen et al., 2004). Beyond age, binge drinkers may be more variable than popular and academic understandings allow for and the challenge is to provide a more diverse account of binge drinkers and the effects associated with types of binge drinking patterns, without understating the risk of harm. In the current study, despite binge drinkers deviating from expected patterns of impairments in attentional processing, binge drinkers on average reported greater past-week craving than non-binge drinkers, and 80% of binge drinkers had AUDIT scores that would categorise them as hazardous drinkers. This apparent diversity in binge drinking effects should motivate future research and public health policy and campaigns to avoid focusing on student populations at the expense of other vulnerable binge drinkers. Distinctions such as heavy and light, and duration of drinking pattern could assist in more accurately categorising these drinkers and assessing the effects and risks they experience.

4.4.3. Applied

Some of the findings presented in this study support a combined intervention. The delivery of experimental manipulations over a task to increase sense of control did not increase personal or task-specific sense of control as predicted, failing to support previous findings (Shamloo & Cox, 2014) but did seem to offer some protective effect against increased craving for alcohol otherwise seen as a trend among binge drinkers who did not receive this intervention. The major motivation behind adding an intervention to increase sense of control to one aiming to decrease attention bias was to address the failure of attention retraining procedures to reduce subjective craving, which is theoretically and practically linked to drug seeking and drug use (Field et al., 2009). While support is modest, the current findings indicate the use of an adjunct sense of control training to decrease craving.

4.5. Future directions

It has been discussed that the sense of control training might be most effective if using the ABM task as a vehicle for delivery instead of, or as well as, separate problem-solving-type tasks designed for intervention delivery. Separate tasks are useful in assessing the intervention itself from a perspective of research design, but the practical or clinical effects might be enhanced if intervention elements, such as choice and reinforcement, are applied to the attention intervention. This could be achieved without adding much time to the ABM procedure, unlike the combined intervention which was performed in two stages, and offers opportunities for standardised delivery as the visual dot-probe is a computerised task. Similar gamification of the ABM has been previously successful in the realm of emotional disorders after a single session (Dennis & O'Toole, 2014), although it is acknowledged that appetitive biases may be harder to retrain. Even in the face of likely small effect sizes of ABM on attention bias (Beard et al., 2012), there is potential for ABM with sense of control enhancements as an adjunct therapy given its targeted focus on automatic cognitions, and its efficiency in being able to deliver training inexpensively and with minimal therapist contact. Such trials should target binge drinkers with more established patterns of binge drinking who might benefit more from any training effects. Future studies also need to explore benefits of repeated sessions, and the retention of benefits beyond the treatment sessions.

4.6. Conclusion

Contrary to what has been demonstrated in other patterns of drinking, the current study found no evidence of alcohol attention bias in binge drinkers beyond a non-significant trend in behavioural measures. This raises the possibility that binge drinkers are a more heterogeneous group than academic, policy, or popular conceptions portray, which poses a challenge to future research to provide or consider a diverse account of binge drinkers, without understating the risk of harm.

There was mixed support for the use of two brief interventions. Although the control intervention was not able to increase personal or task-specific sense of control ratings, it holds potential for reducing craving as it protected binge drinkers against increases in craving seen if untrained. The attention intervention, by way of attention bias modification, was not able to decrease attention bias in binge drinkers, but should be further investigated with binge drinkers with more advanced patterns of binge drinking. Despite this, there was support for

the superiority of the combined intervention as it was better than no training on the measure of alcohol consumption. These warrant further investigation with other binge drinkers that more carefully considers the extent and duration of their drinking pattern and the tasks used to deliver the control intervention.

Appendices

Appendix A. Recruitment advertisement.

New Zealand Brain Research Institute

UC UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

PARTICIPANTS WANTED

EEG Study: Alcohol, Personality and Attention

Looking for people aged 18-50, who drink alcohol	EEG headcap records brain activity	Participants receive a $20 voucher for their time
to complete some questionnaires + simple problem-solving tasks + a visual task	@ NZ Brain Research Institute 66 Stewart Street (near CHCH hospital)	(one session of 2—2½ hours)

visit **http://bit.ly/1EZkNH1**
for more details and to sign up
or ✉ jessica.langbridge@pg.canterbury.ac.nz

This study has been reviewed and approved by the University of Canterbury Human Ethics Committee

Appendix B. Screening survey with display logic.

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

EEG Study: Alcohol, Personality and Attention
INFORMATION SHEET

This survey (approx. 5 minutes) will determine whether you are able to sign up for the research study. Please read this information carefully. Participation in the survey and the study is completely voluntary (your choice).

Study information
If you are eligible and would like to be involved, you will be asked to complete some questionnaires, some simple problem-solving and a visual attention task at the NZ Brain Research Institute (66 Stewart Street, Christchurch). An EEG (electroencephalogram) headcap will monitor brain activity.

Participation involves one session of 2 - 2.5 hours. Participants will receive a $20 voucher for their time.

To be involved in this study, participants need:
(1) to be between 18 and 50 years old,
(2) to have no family history of alcoholism
(3) have no current, regular psychoactive drug use (e.g., antipsychotics, antidepressants etc.), and no regular recreational drug use.

This survey will determine whether you can sign up.
If you are not able to sign up, this could be because there are currently enough participants with responses similar to yours or because you do not meet one of the criteria.

Withdrawal from the study
Completing these questions is voluntary and does not oblige you to participate in the full study. You can leave the study at any time, and can choose to withdraw your information from this survey by contacting the researcher.
Confidentiality
The information you provide will be completely confidential: Your data will be coded so that your identity is not available to anyone, and data gathered from this investigation will be securely stored and only available to the research team. All data collected for the study will be kept in locked and secure facilities and/or in password protected electronic form, and will be destroyed after five years.
Researchers
This study is being conducted by Jessica Langbridge, a Masters thesis research student at the University of Canterbury and the New Zealand Brain Research Institute, as a requirement for a Master of Arts thesis under the supervision of Dr. Juan Canales, Prof. Richard Jones and Paul Russell.
Ethics
This project has been reviewed and approved by the University of Canterbury Human Ethics Committee, and participants should address any complaints to The Chair, Human Ethics Committee, University of Canterbury, Private Bag 4800, Christchurch (human-ethics@canterbury.ac.nz).

If you have any questions about participating in the project, please feel free to contact the primary researcher, Jessica Langbridge (jessica.langbridge@pg.canterbury.ac.nz).

Please answer the following questions (approx. 5 minutes) to see if you are eligible to take part >>

Please describe yourself:

- Male
- Female
- Other gender

What is your age?

>>

How often do you have a drink containing alcohol?

- Never
- Monthly or less
- 2-4 times a month
- 2-3 times a week
- 4 times or more a week

>>

Answer If “How often do you have a drink containing alcohol?” Never Is Selected

Select the response that best describes you.

- I am a non-drinker
- I only have one drink on a special occasion (e.g., a birthday or a holiday)
- These do not describe me

<< >>

If “These do not describe me.” Is Not Selected, Then Skip To End of Block

How often during the last year have you failed to do what was normally expected of you because of drinking?

- Never
- Less than monthly
- Monthly
- Weekly
- Daily or almost daily

How often in the last year have you needed a first drink in the morning to get you going after a heavy drinking session?

- Never
- Less than monthly
- Monthly
- Weekly
- Daily or almost daily

How many standard drinks containing alcohol do you have on a typical day when you are drinking?

A standard drink would be 330ml can of beer, a 100ml glass of wine, or a 30ml of straight spirits.

Click here for some examples .

- 1 or 2
- 3 or 4
- 5 or 6
- 7 to 9
- 10 or more

How often do you have six or more standard drinks on one occasion?

This would be equivalent to 6 cans or bottles of beer, 6 glasses of wine, or 6 drinks containing one shot of liquor or spirits.

- Never
- Less than monthly
- Monthly
- Weekly
- Daily or almost daily

How often during the last year have you found that you were not able to stop drinking once you had started?

- Never
- Less than monthly
- Monthly
- Weekly
- Daily or almost daily

How often in the last year have you had a feeling of guilt or remorse after drinking?

- Never
- Less than monthly
- Monthly
- Weekly
- Daily or almost daily

How often during the last year have you been unable to remember what happened the night before because of your drinking?

- Never
- Less than monthly
- Monthly
- Weekly
- Daily or almost daily

Have you or someone else been injured because of your drinking?

- No
- Yes, but not in the last year
- Yes, during the last year

Has a friend, relative, doctor, or other health care worker been concerned about your drinking or suggested you cut down?

- No
- Yes, but not in the last year
- Yes, during the last year

<< >>

When you do drink, how fast do you drink?
(Here, a drink is a glass of wine, a glass of or one drink of liquor – straight or mixed.)

- 7 or more drinks per hour
- 6 drinks per hour
- 5 drinks per hour
- 4 drinks per hour
- 3 drinks per hour
- 2 drinks per hour
- 1 drink per hour
- 1 drink in 2 hours
- 1 drink in 3 or more hours
- (I do not drink at all.)

How many times have you gotten drunk in the last 6 months?
(Here, "drunk" means loss of coordination, nausea, and/or inability to speak clearly.)

What percentage of the times that you do drink, do you get drunk?

>>

Answer If (BingeScore) Is Greater Than or Equal to 24 And (AUDITScore) Is Less Than or Equal to 20

Answer If (BingeScore) Is Less Than 16 And (AUDITScore) Is Less Than or Equal to 8

Are you a current smoker?

- Yes
- No

Do you have a family history of alcoholism?
Remember that this information will be kept confidential, and will be discarded if you do not participate in the study.

- Yes
- No

Are you **currently** taking any "psychoactive" drugs (e.g. antidepressants, anxiety medication, antipsychotics),
or **regularly** using recreational drugs?
Remember that this information will be kept confidential, and will be discarded if you do not participate in the study.

- Yes
- No

>>

Thank you for your responses. You might be able to participate later.

Our study is investigating alcohol use, personality and cognitive function, using EEG technology to monitor brain activity. Participants will receive a $20 voucher for their time in the study.

EEG cap

Would you like the researcher to get in touch with more information?

- (•) Yes
- ( ) No

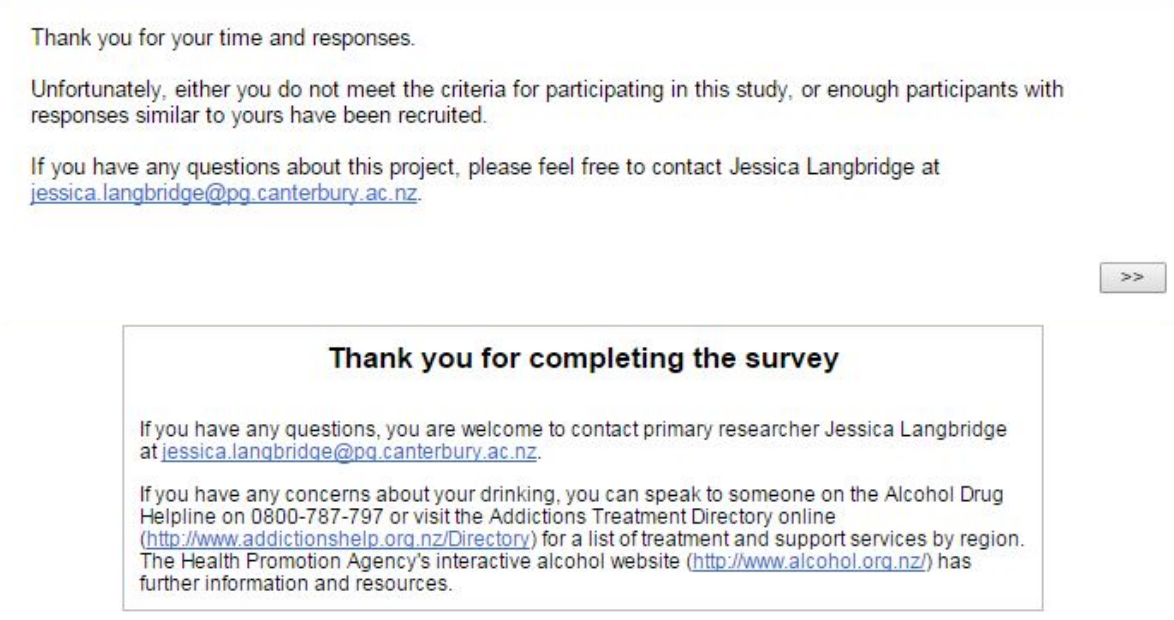
<< >>

Answer If “Thank you for your responses. We are looking for participants like you! Our study is investigating alcohol use, personality and cognitive function, using EEG technology to monitor brain activity. Pa...” Yes Is Selected

Answer If “What is your age?” is less than 18 or greater than 50

Answer If “How often do you have a drink containing alcohol?” Never Is Selected

Answer If (AUDITScore) is Greater Than 20



Appendix C. Information sheet.

Department of Psychology
Telephone: +64 22 677 8595
Email: jessica.langbridge@pg.canterbury.ac.nz
20 May 2015

Information Sheet
EEG Study: Alcohol Use, Personality and Visual Attention

You are invited to take part in the research project titled "Alcohol Use, Personality and Visual Attention". Please take the time to read his information sheet carefully and consider whether you would like to participate. Your participation is entirely voluntary (your choice).

Study information

This study will investigate how alcohol consumption patterns affect visual attention and the roles that personality and cognition play in maintaining those visual attention features. It is expected that this research will contribute to our understanding of how social drinking by non-dependent individuals can affect the brain.

To carry out this research, I am recruiting people aged 18 to 50. If you are eligible and would like to be involved, you will be asked to complete some simple tasks the NZ Brain Research Institute (66 Stewart Street, Christchurch). While you do this, a cap placed on your head will monitor brain activity (EEG/electroencephalography). Participation involves one session only of 2 - 2½ hours, and participants will receive a $20 voucher for their time at the end of this session.

To be involved in this study, participants need (1) to be between 18 and 50 years old, (2) to have no family history of alcoholism and (3) have no current, regular psychoactive drug use (e.g., antipsychotics, antidepressants etc.), and no regular recreational drug use.

The 5-minute survey will determine whether you can sign up >> http://bit.ly/1JxKfri
(If you are not able to sign up, this could be because there are currently enough participants with responses similar to yours or because you do not meet one of the criteria.)

Reimbursement

At the end of their session, participants will receive a $20 voucher for their time.

Benefit

While participating in this research will have no direct benefits for participants personally, we expect that findings from this research will highlight the effects of alcohol consumption patterns on visual attention. Similar research has already been incorporated into treatment approaches for dependent drinkers, and this study could contribute to our understanding of how social drinking by non-dependent individuals can affect the brain.

Withdrawal from the study

Completing these questions is voluntary and does not oblige you to participate in the full study. You can leave the study at any time, and can choose to withdraw your information from this survey by contacting the researcher.

Confidentiality

The information you provide will be completely confidential: Your data will be coded so that your identity is not available to anyone, and data gathered from this investigation will be securely stored and only available to the research team. All data collected for the study will be kept in locked and secure facilities and/or in password protected electronic form, and will be destroyed after five years.

Researchers

This study is being conducted by Jessica Langbridge, a Masters thesis research student at the University of Canterbury and the New Zealand Brain Research Institute, as a requirement for a Master of Arts thesis under the supervision of Dr. Juan Canales, Prof. Richard Jones and Paul Russell.

Ethics

This project has been reviewed and approved by the University of Canterbury Human Ethics Committee, and participants should address any complaints to The Chair, Human Ethics Committee, University of Canterbury, Private Bag 4800, Christchurch (human-ethics@canterbury.ac.nz).

If you have any questions about participating in the project, please feel free to contact the primary researcher, Jessica Langbridge (jessica.langbridge@pg.canterbury.ac.nz).

Appendix D. Consent form.

Department of Psychology
Telephone: +64 22 677 8595
Email: jessica.langbridge@pg.canterbury.ac.nz
19 January 2015

New Zealand Brain Research Institute

UC UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Alcohol Use Personality and Visual Attention Study: Consent Form

I have been given a full explanation of this project and have had the opportunity to ask questions.
I understand what is required of me if I agree to take part in the research.
I understand that participation is voluntary and I may withdraw at any time without penalty. Withdrawal of participation will also include the withdrawal of any information I have provided should this remain practically achievable.
I understand that any information or opinions I provide will be kept confidential to the researcher, that only the research team will have access to the data, and that any published or reported results will not identify the participants. I understand that a thesis is a public document and will be available through the UC Library.
I understand that all data collected for the study will be kept in locked and secure facilities and/or in password protected electronic form and will be destroyed after five years.

I understand that there are no major risks associated with taking part and how they will be managed. I understand that I am able to receive a report on the findings of the study by contacting the researcher at the conclusion of the project.

I understand that I can contact Jessica Langbridge (jessica.langbridge@pg.canterbury.ac.nz) , or her supervisor (Richard Jones – richard.jones@canterbury.ac.nz) for further information. If I have any complaints, I can contact the Chair of the University of Canterbury Human Ethics Committee, Private Bag 4800, Christchurch (human-ethics@canterbury.ac.nz)

☐ I would like to receive a summary of the results.
☐ I would not like to receive a summary of the results.

By signing below, I agree to participate in this research project.

_____
Name

_____
Signature

_____
Date

Appendix E. Experimental script.

Administration.

🗣 [Greet, introduce self, and thank for coming in.]

First, we'll fit the EEG cap which will stay on for the whole session, so if you'd like to use the bathroom, now is a good time (although it is possible later too). For today's study, we'll complete some questionnaires, two problem-solving tasks, and a visual attention task, all on the computer. The last visual task will take the most time, but after that there will just be a few last questionnaires and we're done. We should be finished by _____ today.

🗎 *Information sheet.* I have an information sheet with more details about the study. This is the one I sent over e-mail, but you're welcome to read it now if you would like, and ask me any questions.

🗎 *Consent form.* Here I have a consent form which makes sure that you understand what we'll be doing today and how your data will be taken care of. It explains that our session is confidential and that data will be de-identified, meaning the personal information is removed and you'll be assigned a number instead so it can't be linked back to you. Finally, the only possible risk is that your eyes might get a bit tired after the visual task, but there will be breaks available. Please read the form and let me know if you have any questions. If not, please sign at the bottom and let me know if you would like to receive a summary of the results.

Thanks for doing that. Now we'll get started with the EEG cap.

EEG cap fitting.

🗣 [Fit cap for size. Next, set up mastoid and visual electrodes, explaining purpose of abrasive gel for skin preparation and the electrolyte gel for conducting electrical signals.]

[Explain that the rest of the electrodes on the cap need to be filled with a gel, and that a syringe will be used to administer it. Show blunt needle and apply to the back of the participant's hand, explaining that it needs to be moved to get past the hair and make contact with the scalp, which might scratch a bit but should not hurt. Continue with 64 channel set up, answering questions as necessary.]

Questionnaires.

🗣 We'll start with some questionnaires on the computer. Read questions carefully, but don't spend too long on them or overthink things: in general, go with your gut instinct. Use the keyboard to answer.

You can start when you are ready and move through the questions in your own time. Let me know if you have any questions, and call me when you are done.

💻 Shapiro Control Inventory; Penn Alcohol Craving Scale; Time-locked craving point 1.

Control intervention tasks ("problem-solving tasks").

🗣 Now we have two problem-solving tasks to complete. I'll describe them briefly now, and again before you start, and there'll be a chance to practice.

One of the tasks is **anagrams**. 🗎 *Anagrams example.* Anagrams are words with the letters rearranged, and your task is to work out what the original word was. We have a practice round before we start.

The other task we'll call "**concept cards**". 🗎 *Concept cards example.* Each card is a random combination of shapes and patterns (one of two shapes, like a circle or a square, in one of two colours, with one of two patterns…). You'll be presented with two cards at a time, and these cards will only have one thing in common. For example, they might both have polka dots, but everything else is different: different shape, different colour, different position, and so on. Your task is to pick out the feature that is common to both cards using the corresponding number key. The possible answers will always be listed on the bottom of the computer screen so you don't have to remember them, and there's a practice round for this task too.

These next questions might seem a bit strange, but I want you to think about how you feel about these two tasks. Again, go with your gut response.

💻 Task-specific sense of control point 1.

💻 Screen offering choice of task (anagrams or concept cards). [Allow time for participants to read the choice option.}

Groups receiving sense of control training:

Choice. 🗣 Here you have a choice of which task you start with. Use the keyboard to make your choice. [Follow script according to their chosen task order.]

Groups not receiving sense of control training:

Choice. 🗣 I'm choosing your tasks for you today. You will be starting with the anagram task. [Make selection on keyboard.]

💻Anagrams task instruction screen and practice round.

🗣 Remember that in this task you will be shown a string of letters, jumbled up, and your task is to identify the English word that they make up. Answer by typing your word with the keyboard and press Enter to send it in. You can also press Enter to send in a blank answer if you want to skip an anagram. All of these anagrams have answers, and they range from relatively easy to relatively difficult. I expect everyone to find some difficult, so don't worry too much if you can't solve some. If it's taking a long time, you can submit a blank answer, and I might suggest we move on. Do you understand the task?

We'll have a quick practice round first, so you can ask any questions you might have

💻 Anagrams task practice round.

💻 Anagrams task.

Groups receiving sense of control training:

🗣 Good job! The task has five rounds of five anagrams each, with a break in the middle. You can start when you're ready, and call me when you're done.

Groups not receiving sense of control training:

🗣 Good job! The task has five rounds of five anagrams each, with a break in between each round. For the first round, I'll time you just to get an idea of how you are doing, but just work at your own pace.

💻 Anagrams: Blocks 2-5 – Deliver training.

Time limit. 🗣Great first round! You're doing pretty well, so to add a bit of a challenge we're going to set a time *goal* for each word. That's like a time limit, but it's okay if you go over it. What do you think is a good goal for each word? [Suggest if necessary.]

That was great – shall we try a new time goal?

Information enhancement Just relax, they can be tricky for most people! / You could try letters that often make a pair / It can be helpful to think of common endings for words / etc….

Contingent positive reinforcement. Good job! / Well done! etc. ...

💻 Concept cards task instruction screen.

🗣 Remember that in this task you will be shown a pair of cards, and your job is to figure out what is common to both of the cards. The possible answers are shown on the screen, and you respond by pressing the matching number key. If you don't know, you can press "6" rather than guessing. Do you understand the task?

We'll have a quick practice round first, so you can ask any questions you might have.

💻 Concept cards practice round.

💻 Concept cards task.

Groups receiving sense of control training:

🗣 Good job! The task has five rounds of five card pairs each, with a break in between each round. You can start when you're ready, and call me when you're done.

Groups not receiving sense of control training:

🗣 Good job! The task has five rounds of five card pairs each, with a break in between each round. For the first round, I'll time you just to get an idea of how you are doing, but just work at your own pace.

💻 Concept cards: Blocks 2-5 – Deliver training.

Time limit. 🗣Great first round! You're doing pretty well, so to add a bit of a challenge we're going to set a time *goal* for each round. That's like a time limit, but it's okay if you go over it. What do you think is a good goal for each round (5 card pairs)? [Suggest if necessary.]

That was great – shall we try a new time goal?

Information enhancement Just relax, they can be tricky for most people! / It can to work through the possible answers one-by-one / Remember that the possible answers are on the screen / etc….

Contingent positive reinforcement. Good job! / Well done! etc. ...

🗣Great job, thank you. Please answer these next questions in relation to the tasks you just completed (the anagrams and the concept cards), and let me know when you're done.

💻Task-specific sense of control point 2

🗣 Thank you. These next questions you've seen before too. Answer about how you're feeling right now.

💻 Personal sense of control point 2. Time-locked craving point 2.

Attention intervention tasks ("visual attention tasks")

🗣Our last task, before those final quick questionnaires, is the **visual attention task**. 🖹*Visual attention task example.* The task starts with a cross in the middle of the screen. Next, a pair of images will flash on the screen quite quickly. Then an arrow, pointing either up or to the right, will replace one of the pictures, so either above or below the cross. Your job is to identify which way the arrow is pointing using the arrow keys on the keyboard. For an up arrow you'll press the up key and for an arrow to the right you'll press the right arrow key. Do you have any questions? We'll have a practice round for this task too.

These next questions you've seen before, but this time I'd like you to think about how you feel about the visual attention task. Again, go with your gut response.

💻 Task-specific sense of control point 3.

💻 "Please adjust your chair…"

🗣 Please adjust your chair so that your eyes are in line with the cross in the middle of the screen. We'll start with a practice round so you can get used to the task and the timing. Remember: you focus on the cross in the middle of the screen, and wait for the arrow that will appear after the pair of pictures. Wherever the arrow shows on the screen, your task is to identify which way the arrow is *pointing*. Answer by pressing the matching arrow key. The computer will give you feedback in the practice round to help you.

💻 Visual attention task practice round

🗣 Great job! Now for the full task. Try to work quickly but accurately. You might make a couple of mistakes, especially later in the task if you feel a bit tired, and that's okay. If you feel yourself making a lot of mistakes in a row, slow down a bit until you feel you are answering more accurately. If you are comfortable, try speeding up a bit.

The EEG cap is quite sensitive to movement, so please try to stay relatively still and avoid touching your head. There will be breaks in between rounds for you to move and stretch if you would like. When you're ready you can start the first round, and I'll talk to you again after that.

💻 Visual attention task pre-test

🗣 How did you find that? That was your first round, and you have six more. In between rounds a screen like this one will show for your break. You can make the breaks as long or as short as you'd like. It's a good time to rest your eyes and stretch if you need to. I'll be in the room with you at the other desk, so you can also ask questions in the breaks.

When you are ready you can start the task again and move through in your own time.

💻 Visual attention task, blocks 2-7.

🗣 Great job! Thanks very much for doing that – I know it can be quite long. Just a few last questions and the study is finished!

Final questionnaires.

🗣 Answer these first questions in relation to the task you just completed, the visual attention task.

💻 Tasks-specific sense of control point 4.

💻 SummarySCI point 3; Time-locked craving point 3.

🗣Great, we're finished now! [Help participant out of the EEG cap and remove drop-down electrodes.]

Awareness test. Do you have any comments about the visual attention task? Did you think you noticed any patterns? [Record awareness of task's purpose.]

Taste test.

🗣 The study is finished now. Thanks very much for your help!

Before you go, there is an option for you to help with another task for a future experiment we're planning. We're hoping to use alcohol in a new study, but first we need to check people's reaction to the drinks we want to use. If you'd like to help out, you can participate in a taste test. It involves trying one alcoholic drink and one non-alcoholic drink and answering a short survey about the drinks. The time is now ____ and the taste test would take us to about ____. Again, it's completely voluntary. Would you like to participate?

📄 Taste test survey.

🗣 Here are your samples, one alcoholic and one non-alcoholic, and here is the survey. It asks you to rate each drink on a couple of characteristics, such as sweetness or bitterness, and then give an overall impression of each drink. Have as much or as little of each drink as

you would like in order to be able to answer the questions. Let me know when you're finished.

[Remove drinks from view when participant has completed survey.] Thank you for your help with that.

Debriefing.

🗎 Debriefing form

🗣 The last thing to do before you leave is to go through this debriefing form, which tells you what this study was about. You can take this copy home with you.

[Read through debriefing form with participant. Explain whether they were included as a binge drinking or a non-binge drinking control participant using their binge score from the screening survey. Include the participant's AUDIT score as a measure of how hazardous or not hazardous their drinking might be. Use the Health Promotion Agency booklet to place in the context of low/medium/high risk brackets for their sex. After explaining the purpose of the tasks and expected results, ask for any questions.]

🗎 Incentive.

[Ask participant to sign incentive receipt form]

🗣 [Thank participant for their time]

Appendix F. Taste test survey.

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Tick the box that best describes each characteristic:

	Fruit Juice			Beer		
	Too much	Just Enough	Not Enough	Too Much	Just Enough	Not Enough
After taste	☐	☐	☐	☐	☐	☐
Aroma	☐	☐	☐	☐	☐	☐
Bitterness	☐	☐	☐	☐	☐	☐
Strength	☐	☐	☐	☐	☐	☐
Sweetness	☐	☐	☐	☐	☐	☐

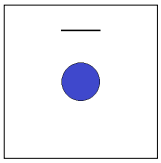
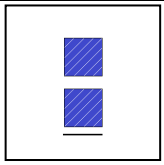
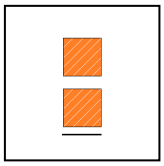
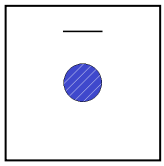
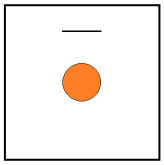
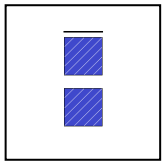
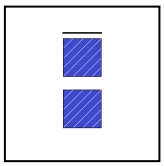
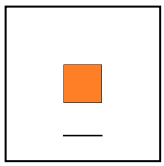
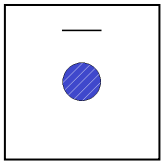
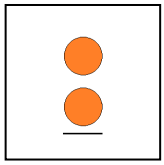
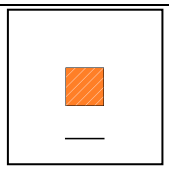
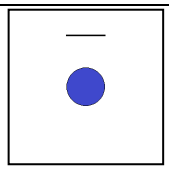
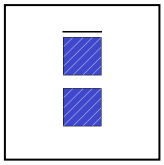
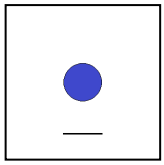
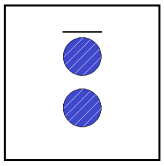
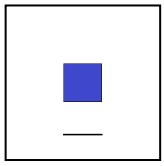
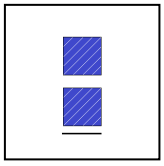
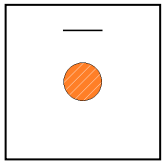
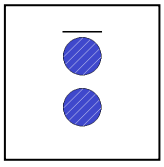
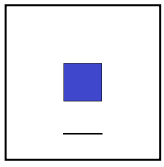
How pleasant are the drinks?

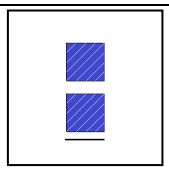
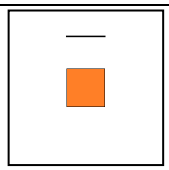
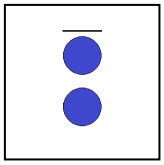
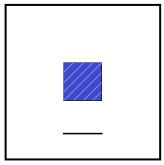
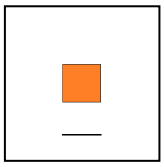
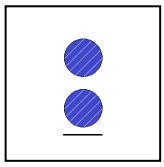
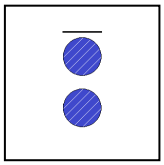
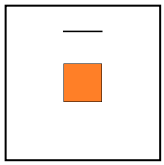
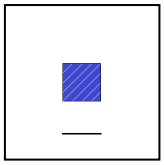
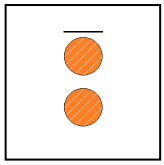
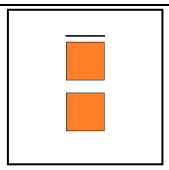
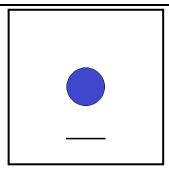
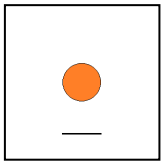
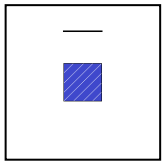
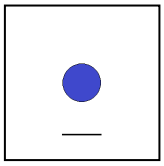
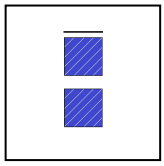
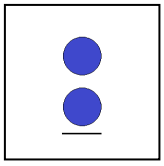
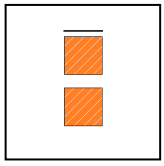
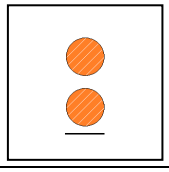
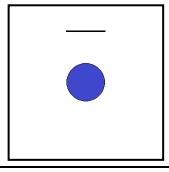
	Poor		Fair		Good		Very Good		Excellent	
	0	10	20	30	40	50	60	70	80	90	100
Fruit Juice											
Beer											

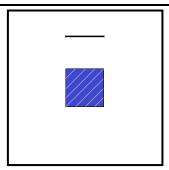
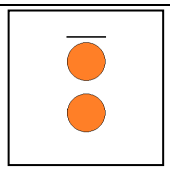
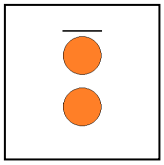
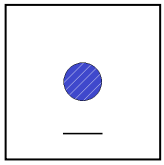
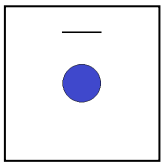
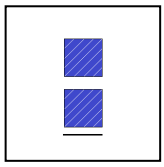
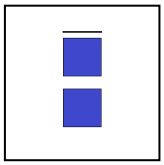
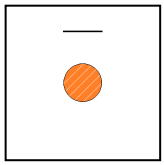
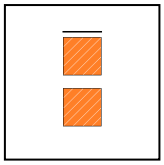
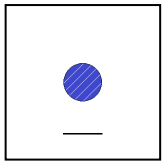
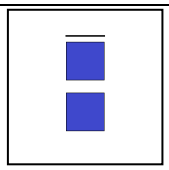
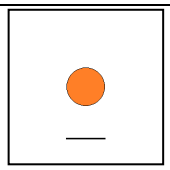
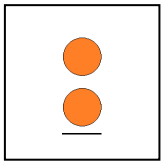
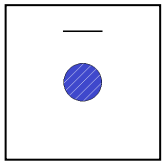
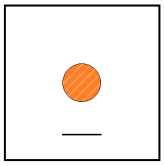
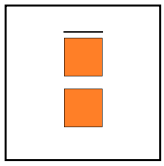
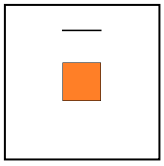
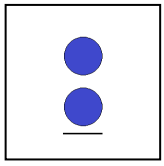
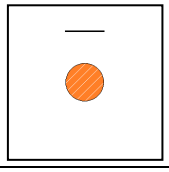
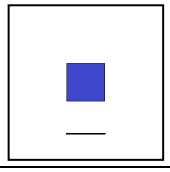
Appendix G. Anagrams used in the control intervention.

Block	Anagram	Correct answer
Practice	N I D F	find
	D S R W O	words
1	R A H P S	sharp
	K C U Y L	lucky
	I U R T F	fruit
	I A L M C	claim
	A T E L M	metal
2	M L I S F	films
	A E R M C	cream
	E N I S M	wrote
	A D H O S W	shadow
	L D O E G N	golden
3	N A R D G	grand
	W O R N B	brown
	D N I S K	kinds
	R M I L F Y	firmly
	Y I A N P G	paying
4	N O H E P	phone
	B U O T D	doubt
	V A R E B	brave
	L O E N B G	belong
	O V L E G S	gloves
5	B M I L S	limbs
	P A R H G	graph
	I G A C M	magic
	R P A E C T	carpet
	U N A C L H	launch

Appendix H. Concept identification cards used in control intervention.

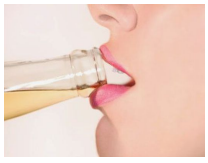
Block	Card 1	Card 2	Correct answer
Practice			Colour
			Pattern
			Line
			Shape
			Shape
1			Number
			Colour
			Colour
			Pattern
			Colour

2			Shape
			Colour
			Line
			Line
			Pattern
3			Pattern
			Number
			Colour
			Number
			Shape

4			Line
			Shape
			Colour
			Line
			Pattern
5			Pattern
			Shape
			Colour
			Pattern
			Number

Appendix I. Pictures pairs used in the attention bias modification task.

Pair	Alcohol image	Neutral image
1		
2		
3		
4		
5		
6		
7		
8		

9		
10		
11		
12		
13		
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Appendix J. Debriefing form.

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Alcohol Use and Visual Attention Study: Debriefing Form

This study is concerned with attentional bias and craving in alcohol users. Previous studies have shown that alcohol users have a greater alcohol attention bias than non-drinkers or light drinkers. This means that alcohol-related items grab the attention of regular/heavy drinkers more. This difference is very small (measured as a fraction of a second in responding time), but in people with alcoholism this attention bias may be important to their treatment.

In this study I am investigating whether people who binge-drink also have an attention bias for alcohol. If so, I want to know if their visual attention can be trained away from alcohol. Training visual attention works with other types of drinkers, but usually has no effect on alcohol craving. Increasing personal sense of control can sometimes decrease craving, so I am looking at decreasing attention bias and increasing personal sense of control.

In this study, all participants performed the problem-solving tasks and the visual attention task, but there were some differences. Some participants completed the problem-solving with extra features added by the researcher that should increase personal sense of control, while others just did the tasks. In the visual attention task, some participants were trained to focus their attention away from the alcohol-related pictures, while others did the task with no training. Finally, all participants could complete an optional "taste test" of an alcoholic and a non-alcoholic drink.

When I examine the data (from the EEG recordings and from answers and reaction times recorded by the computer), I expect that those who binge-drink will focus their attention on the alcohol-related pictures more than other participants. After training, this attention bias should be reduced. I expect that those who problem-solved with the extra features should have increased personal sense of control and reduced craving compared to other participants. I want to study whether these two tasks together (sense of control and attention bias "interventions") are stronger than either alone.
Lastly, I am interested in these interventions and their effect on motivation to drink. The taste test was actually measuring how much alcohol was consumed, and I expect that those who received an intervention would have consumed slightly more than those who did not receive an intervention (relative to the non-alcoholic drink consumed).

It is very important to note that these differences between people are very subtle: for example, changes in attention bias are measured in fractions of a second, or in minute changes in the brain's electrical activity. These measures would not have much application to your daily life, although these

small details may help our understanding of treatment programmes for those with serious drinking problems.

More information about alcohol and drinking guidelines, and interactive resources are given by the Health Promotion Agency at http://www.alcohol.org.nz. If you have any concerns about your drinking, you can talk to someone on the Alcohol Drug Helpline on 0800-787-797 or visit the Addictions Treatment Directory online for a list of treatment and support services by region (http://www.addictionshelp.org.nz/Directory) .

If you have any questions about this study or would like to receive a report of this research when it is completed, please contact Jessica Langbridge at jessica.langbridge@pg.canterbury.ac.nz. If you have any complaints, please contact the Chair of the University of Canterbury Human Ethics Committee, Private Bag 4800, Christchurch (human-ethics@canterbury.ac.nz).

Thank you again for your participation.

Appendix K. Correlations.

Table K.1. Table of correlations for all participants (n = 51, unless otherwise specified). * indicates that a correlation is significant at $p < .05$, and ** indicates that a correlation is significant at $p > .01$.

			Drinking		Craving		Sense of Control						Attention bias			Taste test (n = 38)		
		Age	AUDIT	Binge score	PACS	TLC-1	SCI Overall	SCI Positive	SCI Negative	SCI Desire for	Summary SCI-1	TSSCI-1	Pre-test	Post-test	Difference	Orange juice consumed	Beer consumed	Total fluid consumed
AUDIT	*r*	0.241																
	p	0.089																
Binge score	*r*	-.003	.722**															
	p	.984	.000															
PACS	*r*	.137	.615**	.520**														
	p	.339	.000	.000														
TLC-1	*r*	.118	.229	.101	.344*													
	p	.411	.106	.481	.013													
SCI Overall	*r*	.057	.009	-.022	-.148	.163												
	p	.691	.950	.877	.301	.254												
SCI Positive	*r*	.093	-.023	-.033	-.193	.317*	.933**											
	p	.518	.873	.816	.175	.024	.000											
SCI Negative	*r*	.037	-.068	-.009	-.004	.209	-.708**	-.407**										
	p	.796	.635	.948	.978	.141	.000	.003										
SCI Desire	*r*	-.164	-.040	-.012	.031	.288*	.003	.102	.191									
	p	.250	.778	.931	.831	.040	.982	.478	.178									
Summary SCI-1	*r*	.117	.031	.045	-.001	.295*	.834**	.827**	-.494**	.081								
	p	.413	.828	.752	.996	.036	.000	.000	.000	.574								
TSSCI-1	*r*	.059	-.304*	-.331*	-.255	-.115	.070	.138	.092	.216	-.029							
	p	.682	.030	.018	.071	.422	.624	.336	.522	.129	.839							
Pre-test	*r*	-.292*	-.027	.121	.054	.097	-.101	-.055	.151	.154	-.039	-.037						
	p	.038	.853	.396	.705	.497	.479	.704	.292	.281	.788	.796						
Post-test	*r*	-.027	-.063	-.111	-.028	.292*	-.098	.040	.327*	.010	.051	-.097	.100					
	p	.849	.660	.440	.845	.038	.495	.782	.019	.944	.723	.496	.486					
Difference	*r*	.165	-.035	-.170	-.058	.181	-.016	.068	.175	-.090	.067	-.057	-.560**	.769**				
	p	.247	.805	.233	.684	.205	.910	.635	.218	.528	.640	.690	.000	.000				
Orange juice consumed	*r*	.582**	.179	.025	.102	.397*	.287	.315	-.067	.107	.274	.200	-.130	-.191	-.075			
	p	.000	.281	.880	.542	.014	.080	.054	.689	.523	.096	.228	.437	.252	.656			
Beer consumed	*r*	.588**	.080	-.128	.058	.301	.234	.294	.022	.088	.242	.347*	-.251	-.071	.094	.895**		
	p	.000	.631	.442	.731	.066	.157	.073	.896	.599	.143	.033	.128	.673	.574	.000		
Total fluid consumed	*r*	.601**	.130	-.058	.081	.356*	.266	.312	-.021	.099	.264	.285	-.199	-.131	.015	.970**	.976**	
	p	.000	.435	.731	.630	.028	.106	.056	.903	.552	.109	.082	.230	.434	.929	.000	.000	

Table K.2. Table of correlations for binge drinkers (n = 41, unless otherwise specified). * indicates that a correlation is significant at $p < .05$, and ** indicates that a correlation is significant at $p > .01$.

			Drinking		**Craving**		**Sense of Control**						**Attention bias**			**Taste test (n = 33)**		
		Age	AUDIT	Binge score	PACS	TLC-1	SCI Overall	SCI Positive	SCI Negative	SCI Desire for	Summary SCI-1	TSSCI-1	Pre-test	Post-test	Difference	Orange juice consumed	Beer consumed	Total fluid consumed
AUDIT	*r*	.264																
	p	.095																
Binge score	*r*	-.105	.352*															
	p	.514	.024															
PACS	*r*	.133	.383*	.134														
	p	.406	.014	.403														
TLC-1	*r*	.091	.204	-.014	.357*													
	p	.570	.201	.933	.022													
SCI Overall	*r*	-.011	-.190	-.222	-.212	.112												
	p	.944	.234	.163	.184	.486												
SCI Positive	*r*	.004	-.257	-.246	-.278	.271	.938**											
	p	.980	.105	.121	.078	.086	.000											
SCI Negative	*r*	.034	.013	.110	.028	.203	-.792**	-.530**										
	p	.831	.938	.495	.864	.202	.000	.000										
SCI Desire	*r*	-.187	.029	.015	.003	.263	.066	.167	.132									
	p	.241	.859	.925	.986	.096	.681	.297	.412									
Summary SCI-1	*r*	.053	-.135	-.084	.012	.279	.763**	.754**	-.536**	.126								
	p	.742	.401	.601	.941	.078	.000	.000	.000	.434								
TSSCI-1	*r*	.039	-.248	-.270	-.137	-.144	.006	.040	.054	.202	-.151							
	p	.811	.118	.087	.395	.369	.968	.806	.738	.205	.346							
Pre-test	*r*	-.405**	-.320*	-.127	-.186	.051	-.070	-.038	.102	.221	-.059	.068						
	p	.009	.041	.430	.243	.751	.665	.812	.524	.165	.712	.674						
Post-test	*r*	-.082	.128	.085	.139	.343*	-.160	-.040	.320*	.074	-.010	-.211	.048					
	p	.608	.426	.597	.385	.028	.318	.805	.041	.646	.949	.186	.765					
Difference	*r*	.176	.299	.147	.228	.253	-.090	-.010	.203	-.072	.027	-.215	-.562**	.799**				
	p	.272	.058	.360	.152	.110	.574	.951	.203	.655	.866	.177	.000	.000				
Orange juice consumed	*r*	.653**	.261	.007	.078	.303	.262	.228	-.232	-.177	.214	.196	-.245	-.237	-.051			
	p	.000	.142	.970	.666	.087	.141	.202	.194	.324	.232	.274	.169	.185	.780			
Beer consumed	*r*	.657**	.250	-.048	.128	.189	.179	.177	-.121	-.202	.166	.305	-.373*	-.153	.090	.907**		
	p	.000	.160	.791	.478	.292	.319	.326	.504	.260	.356	.084	.033	.396	.619	.000		
Total fluid consumed	*r*	.671**	.262	-.022	.107	.249	.224	.206	-.178	-.195	.193	.259	-.320	-.197	.024	.974**	.979**	
	p	.000	.141	.901	.555	.162	.211	.251	.322	.277	.281	.145	.070	.271	.896	.000	.000	

Table K.3. Table of correlations for non-binge drinkers (n = 10, unless otherwise specified). * indicates that a correlation is significant at $p < .05$, and ** indicates that a correlation is significant at $p > .01$.

			Drinking		**Craving**		**Sense of Control**						**Attention bias**			**Taste test (n = 5)**		
		Age	AUDIT	Binge score	PACS	TLC-1	SCI Overall	SCI Positive	SCI Negative	SCI Desire for	Summary SCI-1	TSSCI-1	Pre-test	Post-test	Difference	Orange juice consumed	Beer consumed	Total fluid consumed
AUDIT	*r*	.301																
	p	.398																
Binge score	*r*	-.017	.838**															
	p	.963	.002															
PACS	*r*	-.193	.129	.526														
	p	.592	.722	.118														
TLC-1	*r*	.373	.089	.180	.058													
	p	.289	.808	.619	.874													
SCI Overall	*r*	.446	.174	-.163	-.595	.349												
	p	.197	.631	.652	.070	.323												
SCI Positive	*r*	.577	.138	-.191	-.612	.564	.933**											
	p	.080	.703	.598	.060	.089	.000											
SCI Negative	*r*	.138	-.150	-.002	.186	.370	-.539	-.201										
	p	.704	.680	.996	.607	.293	.108	.578										
SCI Desire	*r*	-.175	-.666*	-.449	.112	.490	-.108	.007	.311									
	p	.628	.036	.193	.759	.150	.766	.985	.382									
Summary SCI-1	*r*	.523	-.020	-.347	-.616	.381	.952**	.938**	-.396	-.001								
	p	.121	.955	.326	.058	.278	.000	.000	.257	.998								
TSSCI-1	*r*	.562	-.097	-.488	-.497	.356	.444	.592	.177	.348	.540							
	p	.091	.791	.153	.144	.312	.199	.072	.625	.324	.107							
Pre-test	*r*	.298	-.126	.134	.420	.185	-.308	-.194	.383	.003	-.120	-.276						
	p	.403	.729	.713	.227	.609	.387	.591	.274	.994	.742	.440						
Post-test	*r*	.797**	-.076	-.250	-.224	.195	.190	.367	.343	-.169	.396	.318	.635*					
	p	.006	.834	.487	.535	.589	.599	.296	.332	.641	.258	.371	.048					
Difference	*r*	.610	.053	-.451	-.748*	.021	.579	.661*	-.030	-.205	.610	.696*	-.388	.466				
	p	.061	.884	.191	.013	.954	.079	.037	.935	.571	.061	.025	.268	.175				
Orange juice consumed	*r*	.089	-.549	-.311	.356	.942*	.480	.644	.850	.785	.606	.593	.420	.123	-.294			
	p	.886	.337	.610	.557	.017	.413	.241	.068	.116	.278	.292	.481	.844	.631			
Beer consumed	*r*	.349	-.377	-.120	.647	.959**	.468	.597	.733	.772	.633	.830	.658	.307	-.283	.915*		
	p	.565	.532	.847	.238	.010	.427	.287	.159	.126	.252	.082	.228	.616	.645	.030		
Total fluid consumed	*r*	.234	-.467	-.213	.523	.972**	.484	.633	.804	.795	.634	.736	.560	.226	-.294	.975**	.981**	
	p	.705	.428	.730	.366	.006	.409	.252	.101	.108	.251	.156	.326	.714	.631	.005	.003	

Appendix L. Descriptive statistics for attention bias at baseline, and test statistics for change in attention bias over time.

Table L.1. Attention bias scores at pre-test.

Group	Pre-test Alcohol Attention Bias Scores	
	M	*SD*
1	3.64	16.30
2	6.21	12.60
3	1.60	9.26
4	5.38	17.88
5	-4.32	15.79

Table L.2. Attention bias scores at post-test.

Group	Post-test Alcohol Attention Bias Scores	
	M	*SD*
1	-3.52	20.15
2	-8.10	20.08
3	-5.48	13.08
4	-4.68	24.54
5	3.57	16.44

Table L.3. Test statistics from ANOVA testing change in attention bias scores over time by experimental group.

Effect	*F*	*df*	*p*	*d*	partial η^2
Time	3.81	1	.057	0.58	
Time * E_Group	1.40	4	.249		.109
Between-subjects	0.05	46	.995	0.13	

Appendix M. Descriptive statistics for task performance in the control intervention.

Table M.1. Descriptive statistics for reaction times in the Anagram task. Average reaction times in milliseconds are presented.

Group	Second block		Last block		Overall	
	Mdn	interquartile range	*Mdn*	interquartile range	*Mdn*	interquartile range
1	10653	21853	14928	43999	19340	17017
2	23350	38608	25054	16393	20122	18573
3	18002	42458	20709	20735	19405	22087
4	19596	13948	17254	13140	15226	7909
5	20952	37537	24396	24238	23126	22791

Table M.2. Descriptive statistics for accuracy in the Anagram task. Average scores are presented, out of a total of 5 in the second and last blocks, and out of a total of 25 overall.

Group	Second block		Last block		Overall	
	Mdn	interquartile range	*Mdn*	interquartile range	*Mdn*	interquartile range
1	3.5	2	3.0	2	15.5	9
2	5.0	2	4.0	2	30.0	4
3	3.0	2	4.0	0	18.5	6
4	4.0	2	3.0	2	17.0	7
5	4.0	2	4.0	3	19.5	10

Table M.3. Descriptive statistics for reaction times in the Concept Identification Cards task. Average reaction times in milliseconds are presented.

Group	Second block		Last block		Overall	
	Mdn	interquartile range	*Mdn*	interquartile range	*Mdn*	interquartile range
1	2727	1213	3522	2442	4073	2011
2	3562	1996	4097	1195	4135	2437
3	2693	1996	3294	1694	3193	974
4	3014	1290	6167	3907	4926	1685
5	3034	1726	3809	2076	3699	940

Table M.4. Descriptive statistics for accuracy scores in the Concept Identification Cards task. Average scores are presented, out of a total of 5 in the second and last blocks, and out of a total of 25 overall.

Group	Second block		Last block		Overall	
	Mdn	interquartile range	*Mdn*	interquartile range	*Mdn*	interquartile range
1	5.0	0	5.0	2	25.0	4
2	5.0	0	4.5	2	24.0	5
3	5.0	0	5.0	0	24.0	5
4	5.0	0	4.0	3	22.0	6
5	5.0	0	4.5	2	24.0	4

Appendix N. Test statistics for task performance data.

Table N.1. Wilcoxon Ranked Sign Test for reaction times in the anagram task between second and last blocks.

Group	*n*	*T*	*SE*	Standardised Test Statistic	Sig. (2-tailed)	*r*
1	10	39.00	9.81	1.17	.241	.262
2	9	17.00	8.44	-0.65	.515	-.154
3	10	23.00	9.81	-0.46	.646	-.103
4	11	46.00	11.25	1.16	.248	.246
5	10	21.00	9.81	-0.66	.508	-.148

Table N.2. Wilcoxon Ranked Sign Test for accuracy in the anagram task between second and last blocks.

Group	*n*	*T*	*SE*	Standardised Test Statistic	Sig. (2-tailed)	*r*
1	10	12.50	4.70	0.43	.671	.095
2	10	13.50	7.79	-1.16	.248	-.258
3	10	20.00	6.63	0.30	.763	.068
4	11	2.50	5.80	-1.98	.047	-.423
5	10	13.00	5.80	-0.17	.863	-.038

Table N.3. Wilcoxon Ranked Sign Test for reaction times in the concept identification cards task between second and last blocks.

Group	*n*	*T*	*SE*	Standardised Test Statistic	Sig. (2-tailed)	*r*
1	10	39.00	9.81	1.17	.241	.262
2	10	32.00	9.81	0.46	.646	.103
3	10	52.00	9.81	2.50	.013	.558
4	11	52.00	11.25	1.69	.091	.360
5	10	43.00	9.81	1.58	.114	.353

Table N.4. Wilcoxon Ranked Sign Test for accuracy in the concept identification cards task between second and last blocks.

Group	*n*	*T*	*SE*	Standardised Test Statistic	Sig. (2-tailed)	*r*
1	10	0.00	1.84	-1.63	.102	-.365
2	10	0.00	3.67	-2.04	.041	-.456
3	10	0.00	1.12	-1.34	.180	-.300
4	11	0.00	4.70	-2.23	.026	-.476
5	10	0.00	3.62	-2.07	.038	-.463

Appendix O. Descriptive statistics for ERP amplitudes

Table O.1. Descriptive statistics for amplitudes of the P1 component at site Fz.

	Pre-test				**Post-test**			
	Alcohol		Neutral		Alcohol		Neutral	
Group	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
1	1.81	1.71	2.29	1.90	2.95	1.09	2.37	1.32
2	1.05	3.42	1.37	3.44	2.60	3.27	2.50	3.47
3	1.72	2.03	1.66	2.38	2.33	2.16	2.70	1.79
4	2.05	1.61	2.67	2.05	2.96	1.88	3.17	2.73
5	3.06	3.00	2.16	2.53	3.48	2.15	2.67	1.42
Binge drinkers	1.67	2.24	2.01	2.46	2.72	2.16	2.70	2.40
Non-binge drinkers	3.06	3.00	2.16	2.53	3.48	2.15	2.67	1.42

Table O.2. Descriptive statistics for amplitudes of the P1 component at site FCluster.

	Pre-test				**Post-test**			
	Alcohol		Neutral		Alcohol		Neutral	
Group	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
1	1.50	1.52	1.87	1.57	2.55	1.20	2.21	1.10
2	2.00	2.99	1.26	3.19	2.35	2.97	2.14	3.21
3	1.63	1.97	1.61	2.21	2.00	1.97	2.29	1.60
4	2.00	1.56	2.42	3.16	2.74	1.75	2.91	2.57
5	2.71	2.65	1.89	2.12	2.88	1.82	2.31	1.13
Binge drinkers	1.55	2.03	1.80	2.22	2.42	2.01	2.40	2.22
Non-binge drinkers	2.71	2.65	1.89	2.12	2.88	1.82	2.31	1.13

Table O.3. Descriptive statistics for amplitudes of the P1 component at site Pz.

	Pre-test				**Post-test**			
	Alcohol		Neutral		Alcohol		Neutral	
Group	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
1	1.26	1.85	1.10	1.88	0.80	1.05	1.18	1.23
2	0.26	2.49	0.02	2.06	1.12	1.98	0.70	2.29
3	0.01	1.95	0.23	1.77	0.84	1.28	1.46	1.41
4	0.37	1.30	0.44	1.61	1.10	1.28	0.44	1.29
5	-0.16	2.06	-0.50	3.17	0.73	2.10	0.67	1.94
Binge drinkers	0.47	1.91	0.45	1.81	0.97	1.39	0.93	1.60
Non-binge drinkers	-0.16	2.06	-0.50	3.17	0.73	2.10	0.67	1.94

Table O.4. Descriptive statistics for amplitudes of the P1 component at site PCluster.

	Pre-test				**Post-test**			
	Alcohol		Neutral		Alcohol		Neutral	
Group	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
1	0.74	1.75	0.47	1.81	0.55	1.30	0.82	1.59
2	-0.63	2.16	-0.95	1.80	-0.04	2.03	0.17	1.38
3	-0.35	1.64	-0.29	1.50	0.45	1.22	0.95	1.01
4	-0.10	0.93	-0.01	1.01	0.48	1.15	0.12	0.93
5	-1.06	1.66	-0.83	2.51	0.16	1.68	0.25	1.56
Binge drinkers	-0.09	1.68	-0.19	1.66	0.36	1.42	0.50	1.26
Non-binge drinkers	-1.06	1.66	-0.83	2.51	0.16	1.68	0.25	1.56

Table O.5. Descriptive statistics for amplitudes of the N1 component at site Fz.

	Pre-test				**Post-test**			
	Alcohol		Neutral		Alcohol		Neutral	
Group	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
1	-2.80	2.60	-2.45	2.48	-2.88	1.85	-1.53	1.74
2	-2.89	3.61	-3.80	2.90	-2.31	2.09	-2.51	2.54
3	-1.18	1.48	-1.73	1.78	-1.67	1.40	-1.67	1.46
4	-1.20	2.16	-1.44	1.74	-1.63	2.31	-1.81	2.77
5	-1.59	1.73	-2.47	1.18	-1.59	2.22	-1.38	2.40
Binge drinkers	-2.00	2.61	-1.59	1.73	-2.33	2.37	-2.11	1.95
Non-binge drinkers	-1.59	1.73	-2.47	1.18	-1.59	2.22	-1.38	2.40

Table O.6. Descriptive statistics for amplitudes of the N1 component at site FCluster.

	Pre-test				**Post-test**			
	Alcohol		Neutral		Alcohol		Neutral	
Group	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
1	-2.54	2.60	-2.34	2.42	-2.22	2.32	-1.40	1.73
2	-2.55	3.07	-3.28	2.61	-2.08	1.81	-2.27	2.34
3	-1.14	1.32	-1.71	1.65	-1.58	1.40	-1.46	1.24
4	-1.50	1.71	-1.43	1.63	-1.61	2.30	-1.74	2.66
5	-1.45	1.70	-2.22	1.07	-1.55	2.04	-1.36	2.32
Binge drinkers	-1.92	2.27	-2.17	2.16	-1.87	1.95	-1.72	2.04
Non-binge drinkers	-1.45	1.70	-2.22	1.07	-1.55	2.04	-1.36	2.32

Table O.7. Descriptive statistics for amplitudes of the N1 component at site Pz.

	Pre-test				**Post-test**			
	Alcohol		Neutral		Alcohol		Neutral	
Group	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
1	-4.32	2.52	-3.84	1.95	-3.83	3.19	-3.63	2.22
2	-4.84	2.77	-4.48	2.49	-4.38	2.63	-3.89	2.69
3	-3.42	1.62	-3.51	1.19	-3.78	1.87	-2.66	1.27
4	-2.39	1.60	-2.42	1.18	-3.02	2.06	-3.25	2.00
5	-3.69	1.65	-4.10	1.55	-3.00	1.57	-3.08	1.16
Binge drinkers	-3.17	2.30	-3.54	1.87	-3.74	2.44	-3.35	2.07
Non-binge drinkers	-3.69	1.65	-4.10	1.55	-3.00	1.57	-3.08	1.16

Table O.8. Descriptive statistics for amplitudes of the N1 component at site PCluster.

	Pre-test				**Post-test**			
	Alcohol		Neutral		Alcohol		Neutral	
Group	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
1	-4.76	2.55	-4.17	2.39	-4.43	3.15	-4.10	2.42
2	-5.13	2.43	-4.78	2.42	-4.53	2.33	-4.11	1.97
3	-3.50	1.27	-3.73	1.41	-3.38	1.39	-2.82	1.12
4	-2.79	1.47	-2.77	1.04	-3.37	2.13	-3.52	2.03
5	-3.97	1.42	-4.31	1.36	-3.03	1.44	-3.12	1.37
Binge drinkers	-4.01	2.15	-3.84	1.97	2.31	1.44	-3.63	1.95
Non-binge drinkers	-3.97	1.42	-4.31	1.36	-3.03	1.44	-3.12	1.37

Table O.9. Descriptive statistics for amplitudes of the P3 component at site Fz.

	Pre-test				**Post-test**			
	Alcohol		Neutral		Alcohol		Neutral	
Group	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
1	6.02	2.71	5.57	2.75	5.84	2.76	5.50	1.95
2	7.20	3.48	6.81	2.94	6.46	3.28	5.99	2.92
3	5.74	2.32	5.63	2.16	5.64	2.55	5.49	1.90
4	4.87	2.58	4.57	2.39	5.06	3.44	5.16	3.91
5	6.13	2.42	5.83	2.66	4.47	1.82	4.77	1.93
Binge drinkers	5.93	2.82	5.61	2.60	5.73	4.47	5.23	2.74
Non-binge drinkers	6.13	2.42	5.83	2.66	4.47	1.82	4.77	1.93

Table O.10. Descriptive statistics for amplitudes of the P3 component at site FCluster.

	Pre-test				**Post-test**			
	Alcohol		Neutral		Alcohol		Neutral	
Group	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
1	5.59	2.55	5.20	2.50	5.53	2.50	5.17	1.74
2	6.29	2.96	6.00	2.46	5.89	2.98	5.51	2.55
3	5.47	2.32	5.37	2.16	5.32	2.52	5.31	1.88
4	4.53	2.32	4.15	2.14	4.89	3.16	4.90	3.52
5	5.54	2.15	5.36	2.33	4.05	1.78	4.27	1.84
Binge drinkers	5.45	2.53	5.15	2.33	5.40	2.73	5.22	2.47
Non-binge drinkers	5.54	2.15	5.36	2.33	4.05	1.78	4.27	1.84

Table O.11. Descriptive statistics for amplitudes of the P3 component at site Pz.

	Pre-test				**Post-test**			
	Alcohol		Neutral		Alcohol		Neutral	
Group	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
1	8.11	3.12	7.75	3.22	7.49	3.08	6.68	2.87
2	9.57	2.98	9.44	2.75	7.76	3.36	7.83	3.26
3	9.04	3.63	9.56	3.60	7.77	2.65	7.49	2.98
4	8.05	3.94	7.27	3.47	6.30	3.19	6.97	3.79
5	8.16	2.71	7.82	2.87	6.34	2.34	6.14	2.32
Binge drinkers	8.68	3.39	8.48	3.32	7.30	3.03	7.23	3.17
Non-binge drinkers	8.16	2.71	7.82	2.87	6.34	2.34	6.14	2.32

Table O.12. Descriptive statistics for amplitudes of the P3 component at site PCluster.

	Pre-test				**Post-test**			
	Alcohol		Neutral		Alcohol		Neutral	
Group	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
1	8.03	3.11	7.77	3.33	7.13	2.49	6.52	2.63
2	9.19	2.67	9.10	2.41	7.51	3.06	7.65	2.84
3	8.44	3.33	8.95	3.31	7.39	2.47	7.09	2.59
4	7.31	3.75	6.86	3.62	5.96	3.19	6.64	3.90
5	7.77	2.43	7.54	2.65	5.75	1.89	5.63	1.77
Binge drinkers	8.22	3.21	8.14	3.23	6.97	2.79	6.97	1.76
Non-binge drinkers	7.77	2.43	7.54	2.65	5.75	1.89	5.63	1.77

Appendix P. Test statistics for baseline differences in ERP amplitudes between drinking groups.

P1 component

Table P.1. Results from 2 × 2 ANOVA testing baseline differences in P1 amplitudes at site Pz.

	F	*df*	*p*	*d*	partial η^2
Probe	1.27	1	.265	0.33	
Probe × Group	1.52	1	.223		.031
Between-subjects	1.16	1	.287	0.31	

Table P.2. Results from 2 × 2 ANOVA testing baseline differences in P1 amplitudes at site PCluster.

	F	*df*	*p*	*d*	partial η^2
Probe	3.09	1	.085	0.51	
Probe × Group	1.92	1	.172		.039
Between-subjects	0.99	1	.325	0.29	

Table P.3. Results from 2 × 2 ANOVA testing baseline differences in P1 amplitudes at site Fz.

	F	*df*	*p*	*d*	partial η^2
Probe	0.90	1	.348	0.29	
Probe × Group	1.98	1	.167		.042
Between-subjects	0.25	1	.623	0.14	

Table P.4. Results from 2 × 2 ANOVA testing baseline differences in P1 amplitudes at site FCluster.

	F	*df*	*p*	*d*	partial η^2
Probe	0.63	1	.431	0.24	
Probe × Group	2.29	1	.137		.047
Between-subjects	0.16	1	.687	0.13	

N1 component

Table P.5. Results from 2 × 2 ANOVA testing baseline differences in N1 amplitudes at site Pz.

	F	*df*	*p*	*d*	partial η^2
Probe	0.08	1	.776	0.09	
Probe × Group	0.78	1	.381		.016
Between-subjects	0.11	1	.742	0.09	

Table P.6. Results from 2 × 2 ANOVA testing baseline differences in N1 amplitudes at site PCluster.

	F	*df*	*p*	*d*	partial η^2
Probe	0.02	1	.888	0.00	
Probe × Group	0.93	1	.340		.019
Between-subjects	0.12	1	.732	0.09	

Table P.7. Results from 2 × 2 ANOVA testing baseline differences in N1 amplitudes at site Fz.

	F	*df*	*p*	*d*	partial η^2
Probe	3.77	1	.058	0.56	
Probe × Group	1.40	1	.243		.028
Between-subjects	0.05	1	.828	0.06	

Table P.8. Results from 2 × 2 ANOVA testing baseline differences in N1 amplitudes at site FCluster.

	F	*df*	*p*	*d*	partial η^2
Probe	4.21	1	.046	0.59	
Probe × Group	1.35	1	.252		.027
Between-subjects	0.05	1	.828	0.06	

P3 component

Table P.9. Results from 2 × 2 ANOVA testing baseline differences in P3 amplitudes at site Pz.

	F	*df*	*p*	*d*	partial η^2
Probe	1.73	1	.194	0.38	
Probe × Group	0.12	1	.734		.002
Between-subjects	0.25	1	.623	0.14	

Table P.10. Results from 2 × 2 ANOVA testing baseline differences in P3 amplitudes at site PCluster.

	F	*df*	*p*	*d*	partial η^2
Probe	0.66	1	.420	0.28	
Probe × Group	0.15	1	.697		.003
Between-subjects	0.22	1	.644	0.13	

Table P.11. Results from 2 × 2 ANOVA testing baseline differences in P3 amplitudes at site Fz.

	F	*df*	*p*	*d*	partial η^2
Probe	1.40	1	.242	0.34	
Probe × Group	0.00	1	.975		.000
Between-subjects	0.05	1	.830	0.06	

Table P.12. Results from 2 × 2 ANOVA testing baseline differences in P3 amplitudes at site FCluster.

	F	*df*	*p*	*d*	partial η^2
Probe	1.11	1	.297	0.31	
Probe × Group	0.07	1	.791		.001
Between-subjects	0.03	1	.863	0.06	

Appendix Q. Test statistics for repeated-measures ANOVAs measuring change in ERP amplitude over time by experimental group.

P1 component

Table Q.1. Results from 2 × 2 × 5 ANOVA performed on P1 amplitudes at site Pz.

	F	*df*	*p*	*d*	partial η^2
Probe	0.29	1	.592	0.16	
Probe × Group	0.87	4	.491		.072
Time	10.95	1	.002	0.99	
Time × Group	1.11	4	.365		.090
Probe × Time	0.00	1	.948		.000
Probe × Time × Group	0.17	4	.952		.015
Between-subjects	0.42	4	.792	0.39	

Table Q.2. Results from 2 × 2 × 5 ANOVA performed on P1 amplitudes at site PCluster.

	F	*df*	*p*	*d*	partial η^2
Probe	1.00	1	.331	0.30	
Probe × Group	1.11	4	.364		.094
Time	15.36	1	<.001	1.19	
Time × Group	0.81	4	.525		.070
Probe × Time	0.15	1	.702		.003
Probe × Time × Group	0.19	4	.944		.017
Between-subjects	0.31	4	.870	0.34	

Table Q.3. Results from 2 × 2 × 5 ANOVA performed on P1 amplitudes at site Fz.

	F	*df*	*p*	*d*	partial η^2
Probe	1.05	1	.311	0.31	
Probe × Group	2.95	4	.031		.219
Time	5.83	1	.020	0.71	
Time × Group	0.82	4	.522		.072
Probe × Time	0.25	1	.620		.006
Probe × Time × Group	0.63	4	.647		.056
Between-subjects	0.35	4	.843	0.36	

Table Q.4. Results from 2 × 2 × 5 ANOVA performed on P1 amplitudes at site FCluster.

	F	*df*	*p*	*d*	partial η^2
Probe	1.44	1	.237	0.37	
Probe × Group	2.50	4	.057		.192
Time	9.82	1	.003	0.97	
Time × Group	0.59	4	.675		.053
Probe × Time	1.66	1	.204		.038
Probe × Time × Group	0.30	4	.876		.028
Between-subjects	0.29	4	.883	0.33	

N1 component

Table Q.5. Results from 2 × 2 × 5 ANOVA performed on N1 amplitudes at site Pz.

	F	*df*	*p*	*d*	partial η^2
Probe	2.03	1	.161	0.42	
Probe × Group	0.45	4	.775		.038
Time	2.47	1	.123	0.47	
Time × Group	0.95	4	.445		.078
Probe × Time	1.44	1	.236		.031
Probe × Time × Group	2.06	4	.102		.155
Between-subjects	1.09	4	.373	0.62	

Table Q.6. Results from 2 × 2 × 5 ANOVA performed on N1 amplitudes at site PCluster.

	F	*df*	*p*	*d*	partial η^2
Probe	2.78	1	.103	0.50	
Probe × Group	0.89	4	.492		.071
Time	5.60	1	.022	0.71	
Time × Group	1.29	4	.287		.103
Probe × Time	0.08	1	.784		.002
Probe × Time × Group	1.65	4	.179		.128
Between-subjects	1.41	4	.247	0.71	

Table Q.7. Results from 2 × 2 × 5 ANOVA performed on N1 amplitudes at site Fz.

	F	*df*	*p*	*d*	partial η^2
Probe	0.30	1	.586	0.17	
Probe × Group	1.54	4	.207		.120
Time	4.11	1	.049	0.61	
Time × Group	0.63	4	.645		.053
Probe × Time	3.92	1	.054		.080
Probe × Time × Group	0.67	4	.617		.056
Between-subjects	0.92	4	.459	0.57	

Table Q.8. Results from 2 × 2 × 5 ANOVA performed on N1 amplitudes at site FCluster.

	F	*df*	*p*	*d*	partial η^2
Probe	0.32	1	.573	0.17	
Probe × Group	1.75	4	.156		.135
Time	4.58	1	.038	0.64	
Time × Group	0.55	4	.712		.045
Probe × Time	4.45	1	.004		.090
Probe × Time × Group	0.66	4	.620		.056
Between-subjects	0.66	4	.623	0.48	

P3 component

Table Q.9. Results from 2 × 2 × 5 ANOVA performed on P3 amplitudes at site Pz.

	F	*df*	*p*	*d*	partial η^2
Probe	2.07	1	.157	0.43	
Probe × Group	1.05	4	.391		.085
Time	15.27	1	< .001	1.16	
Time × Group	0.29	4	.880		.025
Probe × Time	0.26	1	.613		.006
Probe × Time × Group	4.06	4	.007		.265
Between-subjects	0.66	4	.625	0.48	

Table Q.10. Results from 2 × 2 × 5 ANOVA performed on P3 amplitudes at site PCluster.

	F	*df*	*p*	*d*	partial η^2
Probe	0.43	1	.516	0.19	
Probe × Group	0.86	4	.496		.071
Time	18.03	1	< .001	1.27	
Time × Group	0.40	4	.809		.034
Probe × Time	0.12	1	.735		.003
Probe × Time × Group	3.40	4	.016		.232
Between-subjects	0.79	4	.537	0.53	

Table Q.11. Results from 2 × 2 × 5 ANOVA performed on P3 amplitudes at site Fz.

	F	*df*	*p*	*d*	partial η^2
Probe	2.18	1	.147	0.44	
Probe × Group	0.36	4	.836		.031
Time	1.23	1	.274	0.33	
Time × Group	0.69	4	.602		.058
Probe × Time	0.71	1	.405		.015
Probe × Time × Group	0.30	4	.879		.026
Between-subjects	0.77	4	.551	0.52	

Table Q.12. Results from 2 × 2 × 5 ANOVA performed on P3 amplitudes at site FCluster.

	F	*df*	*p*	*d*	partial η^2
Probe	2.05	1	.160	0.42	
Probe × Group	0.33	4	.856		.029
Time	0.61	1	.438	0.23	
Time × Group	0.78	4	.543		.065
Probe × Time	0.60	1	.441		.013
Probe × Time × Group	0.21	4	.931		.018
Between-subjects	0.63	4	.644	0.47	

Appendix R. Supplementary analysis of P2 amplitudes.

Table R.1. Descriptive statistics for amplitudes of the P2 component at site Fz.

	Pre-test				**Post-test**			
	Alcohol		Neutral		Alcohol		Neutral	
Group	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
1	3.95	1.77	3.81	1.90	3.75	1.75	3.40	1.71
2	2.44	3.95	2.09	3.49	1.92	3.33	2.61	3.76
3	2.97	2.15	4.06	2.55	3.79	2.15	3.90	2.47
4	2.77	2.21	3.25	1.93	2.42	1.35	2.71	1.77
5	3.89	2.13	3.61	1.78	2.46	1.81	2.87	1.74
Binge drinkers	3.03	2.60	3.89	2.13	3.30	2.56	3.61	1.78
Non-binge drinkers	3.89	2.13	3.61	1.78	2.46	1.81	2.87	1.74

Table R.2. Descriptive statistics for amplitudes of the P2 component at site FCluster.

	Pre-test				**Post-test**			
	Alcohol		Neutral		Alcohol		Neutral	
Group	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
1	3.44	1.53	3.28	1.59	3.22	1.47	3.03	1.42
2	2.36	3.53	2.54	3.36	2.33	3.25	2.67	2.75
3	2.73	1.98	3.71	2.55	3.36	1.98	3.49	2.13
4	2.43	1.85	3.00	1.72	2.23	1.23	2.48	1.63
5	3.53	1.90	3.20	1.55	2.25	1.44	2.57	1.49
Binge drinkers	2.73	2.29	3.13	2.34	2.77	2.09	2.91	2.00
Non-binge drinkers	3.53	1.90	3.20	1.55	2.25	1.44	2.57	1.49

Table R.3. Descriptive statistics for amplitudes of the P2 component at site Pz.

	Pre-test				**Post-test**			
	Alcohol		Neutral		Alcohol		Neutral	
Group	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
1	1.90	1.70	1.93	2.13	1.13	2.23	1.35	1.37
2	1.38	2.52	1.20	2.46	1.66	1.67	1.15	2.73
3	2.49	1.87	2.46	1.91	2.86	0.91	2.60	1.13
4	0.83	1.86	1.36	1.45	0.88	2.12	2.13	2.20
5	2.98	1.87	3.17	2.03	1.69	1.49	2.59	1.73
Binge drinkers	1.58	2.03	1.68	2.00	1.53	1.93	1.74	2.02
Non-binge drinkers	2.98	1.87	3.17	2.03	1.69	1.49	2.59	1.73

Table R.4. Descriptive statistics for amplitudes of the P2 component at site PCluster.

	Pre-test				**Post-test**			
	Alcohol		Neutral		Alcohol		Neutral	
Group	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
1	1.38	1.55	1.29	2.02	0.71	2.13	0.89	1.65
2	0.12	2.96	0.52	2.51	1.30	1.70	0.92	2.11
3	1.75	1.56	1.59	1.54	2.01	1.08	2.05	1.32
4	-0.83	2.43	0.82	2.76	0.62	2.22	1.72	1.71
5	2.38	1.66	0.55	1.76	1.34	1.27	1.97	1.45
Binge drinkers	0.48	2.38	1.02	2.26	1.09	1.91	1.37	1.74
Non-binge drinkers	2.38	1.66	0.55	1.76	1.34	1.27	1.97	1.45

Baseline differences in P2 amplitudes between drinking groups.

Table R.5. Results from 2 × 2 ANOVA testing baseline differences in P2 amplitudes at site Pz.

	F	*df*	*p*	*d*	partial η^2
Probe	0.28	1	.600	0.16	
Probe × Group	0.03	1	<.001		.001
Between-subjects	4.34	1	.043	0.63	

Table R.6. Results from 2 × 2 ANOVA testing baseline differences in P2 amplitudes at site PCluster.

	F	*df*	*p*	*d*	partial η^2
Probe	1.30	1	.260	0.34	
Probe × Group	0.39	1	.534		.008
Between-subjects	4.29	1	.044	0.61	

Table R.7. Results from 2 × 2 ANOVA testing baseline differences in P2 amplitudes at site Fz.

	F	*df*	*p*	*d*	partial η^2
Probe	0.00	1	.995	0.00	
Probe × Group	0.46	1	.502		.009
Between-subjects	0.51	1	.478	0.21	

Table R.8. Results from 2 × 2 ANOVA testing baseline differences in P2 amplitudes at site FCluster.

	F	*df*	*p*	*d*	partial η^2
Probe	0.01	1	.922	0.00	
Probe × Group	1.22	1	.274		.025
Between-subjects	0.34	1	.565	0.17	

Changes in P2 amplitudes by time, probe and experimental group.

Table R.9. Results from 2 × 2 × 5 ANOVA performed on P2 amplitudes at site Pz.

	F	*df*	*p*	*d*	partial η^2
Probe	1.27	1	.267	0.35	
Probe × Group	1.47	4	.229		.125
Time	0.61	1	.439	0.25	
Time × Group	1.64	4	.182		.138
Probe × Time	0.38	1	.539		.009
Probe × Time × Group	0.42	4	.792		.040
Between-subjects	1.49	4	.222	0.76	

Table R.10. Results from 2 × 2 × 5 ANOVA performed on P2 amplitudes at site PCluster.

	F	*df*	*p*	*d*	partial η^2
Probe	2.62	1	.113	0.51	
Probe × Group	1.79	4	.150		.149
Time	0.56	1	.461	0.23	
Time × Group	2.15	4	.092		.173
Probe × Time	0.14	1	.707		.003
Probe × Time × Group	1.12	4	.361		.098
Between-subjects	1.68	4	.173	0.81	

Table R.11 Results from 2 × 2 × 5 ANOVA performed on P2 amplitudes at site Fz.

	F	*df*	*p*	*d*	partial η^2
Probe	1.87	1	.179	0.41	
Probe × Group	1.03	4	.404		.084
Time	2.15	1	.150	0.44	
Time × Group	1.27	4	.294		.102
Probe × Time	0.03	1	.873		.001
Probe × Time × Group	0.70	4	.600		.058
Between-subjects	0.87	4	.487	0.56	

Table R.12. Results from 2 × 2 × 5 ANOVA performed on P2 amplitudes at site FCluster.

	F	*df*	*p*	*d*	partial η^2
Probe	2.60	1	.114	0.48	
Probe × Group	1.08	4	.380		.087
Time	1.91	1	.174	0.41	
Time × Group	1.09	4	.374		.088
Probe × Time	0.06	1	.808		.001
Probe × Time × Group	0.55	4	.703		.046
Between-subjects	0.44	4	.781	0.39	

References

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Washington, D.C: American Psychiatric Association.

Babor, T. F., Caetano, R., Casswell, S., Edwards, G., Giesbrecht, N., Graham, K., . . . Rossow, I. (2010). *Alcohol: No ordinary commodity. Research and public policy* (2nd ed.). Oxford, United Kingdom: Oxford University Press.

Babor, T. F., Higgins-Biddle, J. C., Saunders, J. B., & Monteiro, M. G. . (2001). The Alcohol Use Disorders Identification Test: Guidelines for use in primary care (2nd ed.): World Health Organisation: Department of Mental Health and Substance Dependence.

Barcikowski, R. S., & Robey, R. R. (1984). Decisions in single group repeated measures analysis: Statistical tests and three computer packages. *The American Statistician, 38*(2), 148-150.

Bartholow, B. D., Lust, S. A., & Tragesser, S. L. (2010). Specificity of P3 event-related potential reactivity to alcohol cues in individuals low in alcohol sensitivity. *Psychology of Addictive Behaviors, 24*(2), 220-228. doi: 10.1037/a0017705

Baumeister, R. F., Bratslavsky, E., Muraven, M., & Tice, D. M. (1998). Ego depletion: Is the active self a limited resource? *Journal of Personality and Social Psychology, 74*(5), 1252-1265. doi: 10.1037/0022-3514.74.5.1252

Baumeister, R. F., Vohs, K. D., & Tice, D. M. (2007). The strength model of self-control. *Current Directions in Psychological Science, 16*(6), 351-355. doi: 10.1111/j.1467-8721.2007.00534.x

Beard, Courtney, Sawyer, Alice T., & Hofmann, Stefan G. (2012). Efficacy of attention bias modification using threat and appetitive stimuli: A meta-analytic review. *Behavior Therapy, 43*(4), 724-740. doi: 10.1016/j.beth.2012.01.002

Caplan, L. J., & Schooler, C. (2003). The roles of fatalism, self-confidence, and intellectual resources in the disablement process in older adults. *Psychology and Aging, 18*(3), 551-561. doi: 10.1037/0882-7974.18.3.551

Carretié, L., Hinojosa, J. A., Martín-Loeches, M., Mercado, F., & Tapia, M. (2004). Automatic attention to emotional stimuli: Neural correlates. *Human Brain Mapping, 22*(4), 290-299. doi: 10.1002/hbm.20037

Carretié, L., Martín-Loeches, M., Hinojosa, J. A., & Mercado, F. (2001). Emotion and attention interaction studied through event-related potentials. *Journal of Cognitive Neuroscience, 13*(8), 1109-1128. doi: 10.1162/089892901753294400

Carretié, L., Mercado, F., Tapia, M., & Hinojosa, J. A. (2001). Emotion, attention, and the 'negativity bias', studied through event-related potentials. *International Journal of Psychophysiology, 41*(1), 75-85. doi: 10.1016/S0167-8760(00)00195-1

Carter, Evan C., Kofler, Lilly M., Forster, Daniel E., & McCullough, Michael E. (2015). A series of meta-analytic tests of the depletion effect: Self-control does not seem to rely on a limited resource. *Journal of Experimental Psychology: General, 144*(4), 796-815. doi: 10.1037/xge0000083

Center for Disease Control. (2014). Fact sheets: Binge drinking. from http://www.cdc.gov/alcohol/fact-sheets/binge-drinking.htm

Cohen, Jacob. (1992). A power primer. *Quantitative Methods in Psychology, 112*(1), 155-159.

Connors, G. J., & Volk, R. J. (2003). Self-report screening for alcohol problems among adults. In J. P. Allen & M. Columbus (Eds.), *Assessing alcohol problems: A guide for clinicians and researchers (No. 05–3769)* (2nd ed., pp. 21-35). Bethesda, M.D.: National Institute of Health.

Costa, P. T., & McCrae, R. R. (1985). *The NEO personality inventory manual*. Odessa, F.L.: Psychological Assessment Resources.

Courtney, K. E., & Polich, J. (2009). Binge drinking in young adults: Data, definitions, and determinants. *Psychological Bulletin, 135*(1), 142-156. doi: 10.1037/a0014414

Cox, W. M., Blount, J. P., & Rozak, A. M. (2000). Alcohol abusers' and nonabusers' distraction by alcohol and concern-related stimuli. *American Journal of Drug and Alcohol Abuse, 26*(3), 489.

Cox, W. M., Fadardi, J. S., & Pothos, E. M. (2006). The addiction-Stroop test: Theoretical considerations and procedural recommendations. *Psychological Bulletin, 132*(3), 443-476. doi: 10.1037/0033-2909.132.3.443

Cox, W. M., Hogan, L. M., Kristian, M. R., & Race, J. H. (2002). Alcohol attentional bias as a predictor of alcohol abusers' treatment outcome. *Drug and Alcohol Dependence, 68*(3), 237-243. doi: 10.1016/S0376-8716(02)00219-3

Cox, W. M., Yeates, G. N., & Regan, C. M. (1999). Effects of alcohol cues on cognitive processing in heavy and light drinkers. *Drug and Alcohol Dependence, 55*(1), 85-89. doi: 10.1016/S0376-8716(98)00186-0

Dahm, Theresa, Neshat-Doost, Hamid Taher, Golden, Ann-Marie, Horn, Elizabeth, Hagger, Martin, & Dalgleish, Tim. (2011). Age shall not weary us: Deleterious effects of self-regulation depletion are specific to younger adults. *PLoS One, 6*(10), 1-4. doi: 10.1371/journal.pone.0026351

Dawson, D. A. (2011). Defining risk drinking. *Alcohol Research and Health, 34*(2), 144-156.

Delorme, Arnaud, Miyakoshi, Makoto, Jung, Tzyy-Ping, & Makeig, Scott. (2015). Grand average ERP-image plotting and statistics: A method for comparing variability in event-related single-trial EEG activities across subjects and conditions. *Journal of Neuroscience Methods, 250*, 3-6. doi: 10.1016/j.jneumeth.2014.10.003

Delplanque, S., Lavoie, M. E., Hot, P., Silvert, L., & Sequeira, H. (2004). Modulation of cognitive processing by emotional valence studied through event-related potentials in humans. *Neuroscience Letters, 356*(1), 1-4. doi: 10.1016/j.neulet.2003.10.014

Dennis, Tracy A., & O'Toole, Laura J. (2014). Mental health on the go: Effects of a gamified attention-bias modification mobile application in trait-anxious adults. *Clinical Psychological Science, 2*(5), 576-590. doi: 10.1177/2167702614522228

Duka, T., & Townshend, J. M. (2004). The priming effect of alcohol pre-load on attentional bias to alcohol-related stimuli. *Psychopharmacology, 176*(3), 353-361. doi: 10.1007/s00213-004-1906-7

Eberl, C., Wiers, R. W., Pawelczack, S., Rinck, M., Becker, E. S., & Lindenmeyer, J. (2013). Approach bias modification in alcohol dependence: Do clinical effects replicate and for whom does it work best? *Developmental Cognitive Neuroscience, 4*, 38-51.

Elliot, Andrew J., Faler, Jennifer, McGregor, Holly A., Campbell, W. Keith, Sedikides, Constantine, & Harackiewicz, Judith M. (2000). Competence Valuation as a Strategic Intrinsic Motivation Process. *Personality and Social Psychology Bulletin, 26*(7), 780-794. doi: 10.1177/0146167200269004

Enoch, M.-A. (2006). Genetic and environmental influences on the development of alcoholism. *Annals of the New York Academy of Sciences, 1094*(1), 193-201. doi: 10.1196/annals.1376.019

Esser, Marissa B., Hedden, Sarra L., Kanny, Dafna, Brewer, Robert D., Gfroerer, Joseph C., & Naimi, Timothy S. (2014). Prevalence of alcohol dependence among US adult drinkers, 2009-2011. *Preventing chronic disease, 11*(11), E206. doi: 10.5888/pcd11.140329

Everitt, B. J., Belin, D., Economidou, D., Pelloux, Y., Dalley, J. W., & Robbins, T. W. (2008). Neural mechanisms underlying the vulnerability to develop compulsive drug-seeking habits and addiction. *Philosophical Transactions of the Royal Society B: Biological Sciences, 363*(1507), 3125-3135. doi: 10.1098/rstb.2008.0089

Everitt, B. J., & Robbins, T. W. (2005). Neural systems of reinforcement for drug addiction: From actions to habits to compulsion. *Nature Neuroscience, 8*(11), 1481-1189.

Fadardi, J. S., Cox, W. M., & Klinger, E. (2006). Individualized versus general measures of addiction-related implicit cognitions. In R. W. Wiers & A. W. Stacy (Eds.), *Handbook of implicit cognition and addiction* (pp. 121-133). Thousand Oaks, C.A.: Sage publications.

Fadardi, J. S., & Cox, W. Miles. (2009). Reversing the sequence: Reducing alcohol consumption by overcoming alcohol attentional bias. *Drug and Alcohol Dependence, 101*(3), 137-145. doi: 10.1016/j.drugalcdep.2008.11.015

Fadardi, J. S., Shamloo, Z. S., & Cox, W. M. . (2011). Cognitive and motivational retraining: Reciprocal effects. In W. M. Cox & E. Klinger (Eds.), *Handbook of motivational counseling: Goal-based approaches to assessment and intervention with addiction and other problems* (2nd ed., pp. 850-888). Chichester, United Kingdom: Wiley-Blackwell.

Field, M., & Cox, W. M. (2008). Attentional bias in addictive behaviors: A review of its development, causes, and consequences. *Drug and Alcohol Dependence, 97*(1–2), 1-20. doi: http://dx.doi.org/10.1016/j.drugalcdep.2008.03.030

Field, M., Duka, T., Eastwood, B., Child, R., Santarcangelo, M., & Gayton, M. (2007). Experimental manipulation of attentional biases in heavy drinkers: Do the effects generalise? *Psychopharmacology, 192*(4), 593-608. doi: 10.1007/s00213-007-0760-9

Field, M., & Eastwood, B. (2005). Experimental manipulation of attentional bias increases the motivation to drink alcohol. *Psychopharmacology, 183*(3), 350-357. doi: 10.1007/s00213-005-0202-5

Field, M., Mogg, K., & Bradley, B. P. (2006). Attention to drug-related cues in drug abuse and addiction: Component processes In R. W. Wiers & A. W. Stacy (Eds.), *Handbook of implicit cognition and addiction* (pp. 151-163). Thousand Oaks, C.A.: Sage Publishers.

Field, M., Mogg, K., Zetteler, J., & Bradley, B. P. (2004). Attentional biases for alcohol cues in heavy and light social drinkers: The roles of initial orienting and maintained attention. *Psychopharmacology, 176*(1), 88-93. doi: 10.1007/s00213-004-1855-1

Field, M., Munafò, M. R., & Franken, I. H. A. (2009). A meta-analytic investigation of the relationship between attentional bias and subjective craving in substance abuse. *Psychological Bulletin, 135*(4), 589-607. doi: 10.1037/a0015843

Fox, A. (2015). Understanding behaviour in the Australian and New Zealand night-time economies: An anthropological study. from http://www.lionco.com/content/u12/Dr Anne Fox report.pdf

Fryer, M., Kalafatelis, E., McMillen, P., & Palmer, S. (2004). Standard drink calibration: An in-depth investigation of volumes of alcohol consumed by youth uncontrolled binge drinkers and adult constrained and uninhibited binge drinkers. *(Report number: BRC #2838)*. Wellington, New Zealand.

Gauggel, Siegfried, Hoop, Martina, & Werner, Kirsten. (2002). Assigned versus self-set goals and their impact on the performance of brain-damaged patients. *Journal of Clinical and Experimental Neuropsychology, 24*(8), 1070-1080. doi: 10.1076/jcen.24.8.1070.8377

Glass, David C., Singer, Jerome E., & Friedman, Lucy N. (1969). Psychic cost of adaptation to an environmental stressor. *Journal of Personality and Social Psychology, 12*(3), 200-210. doi: 10.1037/h0027629

Gmel, Gerhard, Kuntsche, Emmanuel, & Rehm, Jürgen. (2011). Risky single-occasion drinking: Bingeing is not bingeing. *Addiction, 106*(6), 1037-1045. doi: 10.1111/j.1360-0443.2010.03167.x

Hakamata, Yuko, Lissek, Shmuel, Bar-Haim, Yair, Britton, Jennifer C., Fox, Nathan A., Leibenluft, Ellen, . . . Pine, Daniel S. (2010). Attention bias modification treatment: A meta-analysis toward the establishment of novel treatment for anxiety. *Biological Psychiatry, 68*(11), 982-990. doi: 10.1016/j.biopsych.2010.07.021

Hallion, Lauren S., & Ruscio, Ayelet Meron. (2011). A meta-analysis of the effect of cognitive bias modification on anxiety and depression. *Psychological Bulletin, 137*(6), 940-958. doi: 10.1037/a0024355

Heinze, H. J., Luck, S. J., Mangun, G. R., & Hillyard, S. A. (1990). Visual event-related potentials index focused attention within bilateral stimulus arrays. I. Evidence for early selection. *Electroencephalography and Clinical Neurophysiology, 75*(6), 511-527. doi: 10.1016/0013-4694(90)90138-A

Herring, R., Berridge, V., & Thom, B. (2008). Binge drinking: An exploration of a confused concept. *Journal of Epidemiology and Community Health, 62*(6), 476-479. doi: 10.1136/jech.2006.056721

Hillyard, Steven A., & Anllo-Vento, Lourdes. (1998). Event-related brain potentials in the study of visual selective attention. *Proceedings of the National Academy of Sciences of the United States of America, 95*(3), 781.

Hiroto, Donald S., & Seligman, Martin E. (1975). Generality of learned helplessness in man. *Journal of Personality and Social Psychology, 31*(2), 311-327. doi: 10.1037/h0076270

Hodges, I., & Maskill, C. (2014). Alcohol and older adults in New Zealand: A literature review. Wellington, New Zealand: Health Promotion Agency.

Hogarth, L. C., Mogg, K., Bradley, B. P., Duka, T., & Dickinson, A. (2003). Attentional orienting towards smoking-related stimuli. *Behavioural Pharmacology, 14*(2), 153-160. doi: 10.1097/00008877-200303000-00007

Huck, S. W., Cormier, W. H., & Bounds, W. G., Jr. (1974). *Reading statistics and research*. New York, N.Y.: Harper & Row.

Huynh, H., & Feldt, L. S. (1976). Estimation of the box correction for degrees of freedom from sample data in randomized block and split-plot designs. *Journal of Educational Statistics, 1*(1), 69-82.

Ichiyama, Michael A., & Kruse, Marc I. (1998). The social contexts of binge drinking among private university freshmen. *Journal of Alcohol and Drug Education, 44*(1), 18-33.

Jones, A., Button, E., Rose, A. K., Robinson, E., Christiansen, P., Di Lemma, L., & Field, M. (2015). The ad-libitum alcohol 'taste test': Secondary analyses of potential confounds and construct validity. *Psychopharmacology*, 1-8. doi: 10.1007/s00213-015-4171-z

Jones, A., & Field, M. (2013). The effects of cue-specific inhibition training on alcohol consumption in heavy social drinkers. *Experimental and Clincal Psychopharmacology, 21*(1), 6-16. doi: 10.1037/a0030683

Jones, B. T., & Schulze, D. (2000). Alcohol-related words of positive affect are more accessible in social drinkers' memory than are other words when sip-primed by alcohol. *Addiction Research, 8*(3), 221-232.

Kim, H.-Y. (2013). Statistical notes for clinical researchers: Assessing normal distribution (2) using skewness and kurtosis. *Restorative Dentistry & Endodontics, 38*(1), 52-54. doi: 10.5395/rde.2013.38.1.52

Klein, Audrey A. (2007). Suppression-induced hyperaccessibility of thoughts in abstinent alcoholics: A preliminary investigation. *Behaviour Research and Therapy, 45*(1), 169-177. doi: 10.1016/j.brat.2005.12.012

Kok, A. (1997). Event-related potential (ERP) reflections of mental resources: A review and synthesis. *Biological Psychology, 45*(1-3), 19-56. doi: 10.1016/S0301-0511(96)05221-0

Kok, A. (2001). On the utility of P3 amplitude as a measure of processing capacity. *Psychophysiology, 38*(3), 557-577. doi: 10.1017/S0048577201990559

Koob, G. F., & Le Moal, M. (1997). Drug abuse: Hedonic homeostatic dysregulation. *Science, 278*(5335), 52-58. doi: 10.1126/science.278.5335.52

Koob, G. F., & Le Moal, M. (2001). Drug addiction, reward dysregulation and allostasis. *BRITISH JOURNAL OF PHARMACOLOGY, 24*(2), 97-129.

Kypri, K., Cronin, M., & Wright, C. S. (2005). Do university students drink more hazardously than their non-student peers? [Letter to the editor]. *Addiction, 100*(5), 713-714. doi: 10.1111/j.1360-0443.2005.01116.x

Langer, Ellen J., & Rodin, Judith. (1976). The effects of choice and enhanced personal responsibility for the aged: A field experiment in an institutional setting. *Journal of Personality and Social Psychology, 34*(2), 191-198. doi: 10.1037/0022-3514.34.2.191

Leech, G., Rayson, P., & Wilson, A. (2001). Companion website for: Word Frequencies in Written and Spoken English: based on the British National Corpus., from http://ucrel.lancs.ac.uk/bncfreq/

Levine, M. (1966). Hypothesis behavior by humans during discrimination learning. *Journal of Experimental Psychology, 71*(3), 331-338. doi: 10.1037/h0023006

Levine, M. (1971). Hypothesis theory and nonlearning despite ideal S-R-reinforcement contingencies. *Psychological Review, 78*(2), 130-140. doi: 10.1037/h0030647

Littel, M., & Franken, I. H. A. (2012). Electrophysiological correlates of associative learning in smokers: A higher-order conditioning experiment. *BMC neuroscience, 13*(8), 1-13. doi: 10.1186/1471-2202-13-8

Locke, Edwin A., & Latham, Gary P. (1990). *A theory of goal setting and task performance*. Englewood Cliffs., N.J: Prentice Hall.

López-Caneda, E., Cadaveira, F., Crego, A., Doallo, S., Corral, M., Gómez-Suárez, A., & Rodríguez Holguín, S. (2013). Effects of a persistent binge drinking pattern of alcohol consumption in young people: A follow-up study using event-related potentials. *Alcohol and Alcoholism, 48*(4), 464-471. doi: 10.1093/alcalc/agt046

López-Caneda, E., Cadaveira, F., Crego, A., Gómez-Suárez, A., Corral, M., Parada, M., . . . Rodríguez Holguín, S. (2012). Hyperactivation of right inferior frontal cortex in young binge drinkers during response inhibition: A follow-up study. *Addiction, 107*(10), 1796-1808. doi: 10.1111/j.1360-0443.2012.03908.x

López-Caneda, E., Rodríguez Holguín, S., Corral, M., Doallo, S., & Cadaveira, F. (2014). Evolution of the binge drinking pattern in college students: Neurophysiological correlates. *Alcohol, 48*(5), 407-418. doi: 10.1016/j.alcohol.2014.01.009

MacEwan, I. (2003). Helping with problem drinking (7th ed.). Wellington, New Zealand: Health Promotion Agency.

MacLeod, Colin, Mathews, Andrew, & Tata, Philip. (1986). Attentional bias in emotional disorders. *Journal of Abnormal Psychology, 95*(1), 15-20. doi: 10.1037/0021-843X.95.1.15

MacLeod, Colin, Rutherford, Elizabeth, Campbell, Lyn, Ebsworthy, Greg, & Holker, Lin. (2002). Selective attention and emotional vulnerability: Assessing the causal basis of their association through the experimental manipulation of attentional bias. *Journal of Abnormal Psychology, 111*(1), 107-123. doi: 10.1037/0021-843X.111.1.107

Marlatt, G. A., Demming, B., & Reid, J. B. (1973). Loss of control drinking in alcoholics: An experimental analogue. *Journal of Abnormal Psychology, 81*(3), 233-241. doi: 10.1037/h0034532

Maurage, Pierre, Pesenti, Mauro, Philippot, Pierre, Joassin, Frédéric, & Campanella, Salvatore. (2009). Latent deleterious effects of binge drinking over a short period of time revealed only by electrophysiological measures. *Journal of Psychiatry and Neuroscience, 34*(2), 111-118.

McCarty, Carolyn A., DiGiuseppe, David L., Garrison, Michelle M., Rivara, Frederick P., Ebel, Beth E., & Christakis, Dimitri A. (2005). Continuity of binge and harmful drinking from late adolescence to early adulthood. *Journal of the American Academy of Child and Adolescent Psychiatry, 44*(6), 521.

McHugh, M. L. (2011). Multiple comparison analysis testing in ANOVA. *Biochemia medica, 21*(3), 203-209.

McKean Skaff, M. (2007). Sense of control and health. In C. M. Aldwin, C. L. Park & A. Spiro, III, (Eds.), *Handbook of health psychology and aging* (pp. 186-209). New York, NY: The Guilford Press.

McMillen, P., Kalafatelis, E., & de Bonnaire, C. (2004). The way we drink: The current attitudes and behaviours of New Zealanders (aged 12 plus) towards drinking alcohol *(Report number BRC #2634/2710)*. Wellington, New Zealand: BRC Marketing & Social Research, & Alcohol Advisory Council of New Zealand.

Measham, Fiona. (2008). The turning tides of intoxication: Young people's drinking in Britain in the 2000s. *Health Education, 108*(3), 207-222. doi: 10.1108/09654280810867088

Mehrabian, A., & Russell, J. A. (1978). A questionnaire measure of habitual alcohol use. *Psychological Reports, 43*(3), 803-806. doi: 10.2466/pr0.1978.43.3.803

Ministry of Health. (2009). Alcohol Use in New Zealand, Key results of the 2007/08 New Zealand Alcohol and Drug Use Survey. Wellington, New Zealand: Ministry of Health.

Ministry of Health. (2013a). Appendix 10: Alcohol and other drugs procedure: AUDIT questionnaire *Well Child / Tamariki Ora Programme practitioner handbook:*

Supporting families and whānau to promote their child's health and development. Wellington, New Zealand: Ministry of Health.

Ministry of Health. (2013b). Hazardous drinking in 2011/2012: Findings from the New Zealand Health Survey. Wellington, New Zealand: Ministry of Health.

Moffitt, Terrie E., Arseneault, Louise, Belsky, Daniel, Dickson, Nigel, Hancox, Robert J., Harrington, HonaLee, . . . Heckman, James J. (2011). A gradient of childhood self-control predicts health, wealth, and public safety. *Proceedings of the National Academy of Sciences of the United States of America, 108*(7), 2693-2698. doi: 10.1073/pnas.1010076108

Mogoaşe, Cristina, David, Daniel, & Koster, Ernst H. W. (2014). Clinical efficacy of attentional bias modification procedures: An updated meta-analysis. *Journal of Clinical Psychology, 70*(12), 1133-1157. doi: 10.1002/jclp.22081

Mucha, R. F., Geier, A., & Pauli, P. (1999). Modulation of craving by cues having differential overlap with pharmacological effect: Evidence for cue approach in smokers and social drinkers. *Psychopharmacology, 147*(3), 306-313. doi: 10.1007/s002130051172

Muraven, Mark, Collins, R. Lorraine, & Nienhaus, Kristen. (2002). Self-control and alcohol restraint: An initial application of the self-control strength model. *Psychology of Addictive Behaviors, 16*(2), 113-120. doi: 10.1037/0893-164X.16.2.113

Murgraff, Vered, Parrott, Andrew, & Bennett, Paul. (1999). Risky single-occasion drinking amongst young people - Definition, correlates, policy, and intervention: A broad overview of research findings. *Alcohol and Alcoholism, 34*(1), 3-14. doi: 10.1093/alcalc/34.1.3

Murugiah, Sera. (2012). A discrepancy of definitions: Binge drinking and female students at an Australian university. *Youth Studies Australia, 31*(2), 26-34.

Namkoong, Kee, Lee, Eun, Lee, Choong Heon, Lee, Byung Ook, & An, Suk Kyoon. (2004). Increased P3 amplitudes induced by alcohol-related pictures in patients with alcohol dependence. *Alcoholism: Clinical and Experimental Research, 28*(9), 1317-1323. doi: 10.1097/01.ALC.0000139828.78099.69

National Institute of Alcohol Abuse and Alcoholism. (2003). Appendix: Instrument fact sheets: Penn Alcohol Craving Scale. In J. P. Allen & M. Columbus (Eds.), *Assessing*

alcohol problems: A guide for clinicians and researchers (2nd ed., pp. 482-486). Bethesda, M.D.: National Institute of Alcohol Abuse and Alcoholism.

National Institute of Alcohol Abuse and Alcoholism. (2014). NIAAA council approves definition of binge drinking. *NIAAA Newsletter, 3*(3), 3. http://pubs.niaaa.nih.gov/publications/Newsletter/winter2004/Newsletter_Number3.pdf

Nolan, H., Whelan, R., & Reilly, R. B. (2010). FASTER: Fully Automated Statistical Thresholding for EEG artifact Rejection. *Journal of Neuroscience Methods, 192*(1), 152-162. doi: 10.1016/j.jneumeth.2010.07.015

Norman, P., Bennett, P., & Lewis, H. (1998). Understanding binge drinking among young people: An application of the Theory of Planned Behaviour. *Health education research, 13*(2), 163-169. doi: 10.1093/her/13.2.163-a

O'Toole, Laura, & Dennis, Tracy A. (2012). Attention training and the threat bias: An ERP study. *Brain and Cognition, 78*(1), 63-73. doi: 10.1016/j.bandc.2011.10.007

Oei, T. P. S., & Morawska, A. (2004). A cognitive model of binge drinking: The influence of alcohol expectancies and drinking refusal self-efficacy. *Addictive Behaviors, 29*(1), 159-179. doi: http://dx.doi.org/10.1016/S0306-4603(03)00076-5

Olofsson, J. K., Nordin, S., Sequeira, H., & Polich, J. (2008). Affective picture processing: An integrative review of ERP findings. *Biological Psychology, 77*(3), 247-265. doi: 10.1016/j.biopsycho.2007.11.006

Olofsson, J. K., & Polich, J. (2007). Affective visual event-related potentials: Arousal, repetition, and time-on-task. *Biological Psychology, 75*(1), 101-108. doi: 10.1016/j.biopsycho.2006.12.006

Palfai, Tibor P., Monti, Peter M., Colby, Suzanne M., & Rohsenow, Damaris J. (1997). Effects of suppressing the urge to drink on the accessibility of alcohol outcome expectancies. *Behaviour Research and Therapy, 35*(1), 59-65. doi: http://dx.doi.org/10.1016/S0005-7967(96)00079-4

Petit, G., Kornreich, C., Dan, B., Verbanck, P., & Campanella, S. (2014). Electrophysiological correlates of alcohol- and non-alcohol-related stimuli processing in binge drinkers: A follow-up study. *Journal of Psychopharmacology, 28*(11), 1041-1052. doi: 10.1177/0269881114545663

Petit, G., Kornreich, C., Maurage, P., Noël, X., Letesson, C., Verbanck, P., & Campanella, S. (2012). Early attentional modulation by alcohol-related cues in young binge drinkers: An event-related potentials study. *Clinical Neurophysiology, 123*(5), 925-936. doi: 10.1016/j.clinph.2011.10.042

Petit, G., Kornreich, C., Verbanck, P., & Campanella, S. (2013). Gender differences in reactivity to alcohol cues in binge drinkers: A preliminary assessment of event-related potentials. *Psychiatry research, 209*(3), 494-503. doi: 10.1016/j.psychres.2013.04.005

Petit, G., Maurage, P., Kornreich, C., Verbanck, P., & Campanella, S. (2014). Binge drinking in adolescents: A review of neurophysiological and neuroimaging research. *Alcohol and Alcoholism, 49*(2), 198-206. doi: 10.1093/alcalc/agt172

Phares, E. Jerry. (1957). Expectancy changes in skill and chance situations. *The Journal of Abnormal and Social Psychology, 54*(3), 339-342. doi: 10.1037/h0045684

Polich, J. (2007). Updating P300: An integrative theory of P3a and P3b. *Clinical Neurophysiology, 118*(10), 2128-2148. doi: 10.1016/j.clinph.2007.04.019

Polich, J. (2012). Neuropsychology of P300. In S. J. Luck & E. Kappenman (Eds.), *Handbook of event-related potential components* (pp. 159-188). New York, NY: Oxford University Press.

Robinson, T. E., & Berridge, K. C. (1993). The neural basis of drug craving: An incentive-sensitization theory of addiction. *Brain Research Reviews, 18*(3), 247.

Robinson, T. E., & Berridge, K. C. (2008). The incentive sensitization theory of addiction: Some current issues. *Philosophical Transactions of the Royal Society B: Biological Sciences, 363*(1507), 3137-3146. doi: 10.1098/rstb.2008.0093

Rodin, Judith. (1986). Aging and health: Effects of the sense of control. *Science, 233*(4770), 1271-1276. doi: 10.1126/science.3749877

Room, R., & Rossow, I. (2001). The share of violence attributable to drinking. *Journal of Substance Use, 6*(4), 218-228.

Rosenthal, R., & DiMatteo, M. R. (2001). Meta-analysis: Recent developments in quantitative methods for literature reviews. *Annual Review of Psychology, 52*(1), 59-82. doi: 10.1146/annurev.psych.52.1.59

Rosenthal, R., Rosnow, R. L., & Rubin, D. B. (2000). *Contrasts and effect sizes in behavioural research: A correlational report*. New York, N.Y.: Cambridge University Press.

Rotter, J. B. (1966). Generalized expectancies for internal versus external control of reinforcement. *Psychological monographs, 80*(1), 1-28.

Ryan, Frank. (2002). Attentional bias and alcohol dependence: A controlled study using the modified Stroop paradigm. *Addictive Behaviors, 27*(4), 471-482. doi: 10.1016/S0306-4603(01)00183-6

Saunders, John B., Aasland, Olaf G., Babor, T. F., De La Fuente, Juan R., & Grant, Marcus. (1993). Development of the Alcohol Use Disorders Identification Test (AUDIT): WHO collaborative project on early detection of persons with harmful alcohol consumption-II. *Addiction, 88*(6), 791-804. doi: 10.1111/j.1360-0443.1993.tb02093.x

Schoenmakers, T. M., de Bruin, Marijn, Lux, Irja F. M., Goertz, Alexa G., Van Kerkhof, Dorieke H. A. T., & Wiers, Reinout W. (2010). Clinical effectiveness of attentional bias modification training in abstinent alcoholic patients. *Drug and Alcohol Dependence, 109*(1), 30-36. doi: 10.1016/j.drugalcdep.2009.11.022

Schoenmakers, T. M., Wiers, R., Jones, B. T., Bruce, G., & Jansen, A. T. M. (2007). Attentional retraining decreases attentional bias in heavy drinkers without generalization. *Addiction, 102*, 399-405.

Schoenmakers, T. M., Wiers, R. W. H. J., & Field, M. (2008). Effects of a low dose of alcohol on cognitive biases and craving in heavy drinkers. *Psychopharmacology, 197*(1), 169-178. doi: 10.1007/s00213-007-1023-5

Schulz, Richard. (1976). Effects of control and predictability on the physical and psychological well-being of the institutionalized aged. *Journal of Personality and Social Psychology, 33*(5), 563-573. doi: 10.1037/0022-3514.33.5.563

Schulz, Richard, & Hanusa, Barbara H. (1978). Long-term effects of control and predictability-enhancing interventions: Findings and ethical issues. *Journal of Personality and Social Psychology, 36*(11), 1194-1201. doi: 10.1037/0022-3514.36.11.1194

Shamloo, Z. S. (2007). *Information enhancement and goal setting: Interventions for enhancing motivation*. (Unpublished doctoral dissertation). University of Wales, Bangor.

Shamloo, Z. S., & Cox, W. M. (2010). The relationship between motivational structure, sense of control, intrinsic motivation and university students' alcohol consumption. *Addictive Behaviors, 35*(2), 140-146. doi: 10.1016/j.addbeh.2009.09.021

Shamloo, Z. S., & Cox, W. M. (2014). Information-enhancement and goal setting techniques for increasing adaptive motivation and decreasing urges to drink alcohol. *Addictive Behaviors, 39*(7), 1205-1213. doi: 10.1016/j.addbeh.2014.03.023

Shapiro, D. H., Jr. (1994). *Manual for the Shapiro Control Inventory*. Palo Alto, CA: Behaviordyne/Behaviordata.

Sharma, Dinkar, Albery, Ian P., & Cook, Chris. (2001). Selective attentional bias to alcohol related stimuli in problem drinkers and non-problem drinkers. *Addiction, 96*(2), 285-295. doi: 10.1046/j.1360-0443.2001.96228512.x

Skinner, Ellen A. (1996). A guide to constructs of control. *Journal of Personality and Social Psychology, 71*(3), 549-570. doi: 10.1037/0022-3514.71.3.549

Stewart, J., de Wit, H., & Eikelboom, R. (1984). Role of unconditioned and conditioned drug effects in the self-administration of opiates and stimulants. *Psychological Review, 91*(2), 251-268. doi: 10.1037/0033-295X.91.2.251

Stotland, E., & Blumenthal, A. L. (1964). The reduction of anxiety as a result of the expectation of making a choice. *Canadian journal of psychology, 18*(2), 139-145. doi: 10.1037/h0083492

Surgenor, Lois J., Horn, Jacqueline, Hudson, Stephen M., Adamson, Simon, & Robertson, Paul. (2006). Alcohol dependence and psychological sense of control: Refining the links. *New Zealand Journal of Psychology, 35*(3), 146-152.

Surrette, M. A., & Harlowe, L. L. (1992). Level of satisfaction and commitment to a decisional choice as mediated by locus of control. *Applied H.R.M. Research, 3*(2), 92-113.

Teunissen, H. A., Spijkerman, R., Schoenmakers, T. M., Vohs, K. D., & Engels, R. C. M. E. (2012). The effect of self-control on attentional bias for alcohol cues in male heavy

drinkers. *Journal of Applied Social Psychology, 42*(3), 776-792. doi: 10.1111/j.1559-1816.2011.00800.x

Tice, Dianne M., Baumeister, Roy F., Shmueli, Dikla, & Muraven, Mark. (2007). Restoring the self: Positive affect helps improve self-regulation following ego depletion. *Journal of Experimental Social Psychology, 43*(3), 379-384. doi: 10.1016/j.jesp.2006.05.007

Tiffany, Stephen T. (1990). A cognitive model of drug urges and drug-use behavior: Role of automatic and nonautomatic processes. *Psychological Review, 97*(2), 147-168. doi: 10.1037/0033-295X.97.2.147

Tomsovic, M. (1974). "Binge" and continuous drinkers: Characteristics and treatment follow-up. *Quarterly journal of studies on alcohol, 35*(Pt A), 558.

Townshend, J. M., & Duka, T. (2001). Attentional bias associated with alcohol cues: Differences between heavy and occasional social drinkers. *Psychopharmacology, 157*(1), 67-74. doi: 10.1007/s002130100764

Townshend, J. M., & Duka, T. (2002). Patterns of alcohol drinking in a population of young social drinkers: A comparison of questionnaire and diary measures. *Alcohol and Alcoholism, 37*(2), 187-192. doi: 10.1093/alcalc/37.2.187

Vik, Peter W., Tate, Susan R., & Carrello, Patrice. (2000). Detecting college binge drinkers using an extended time frame. *Addictive Behaviors, 25*(4), 607-612. doi: 10.1016/S0306-4603(99)00045-3

Wagner, Fernando A., & Anthony, James C. (2002). From first drug use to drug dependence: Developmental periods of risk for dependence upon marijuana, cocaine, and alcohol. *Neuropsychopharmacology, 26*(4), 479-488. doi: 10.1016/S0893-133X(01)00367-0

Wechsler, H., Davenport, A., Dowdall, G., Moeykens, B., & Castillo, S. (1994). Health and behavioral consequences of binge drinking in college: A national survey of students at 140 campuses. *Journal of the American Medical Association, 272*(21), 1672-1677. doi: 10.1001/jama.1994.03520210056032

Wechsler, H., Dowdall, George W., Davenport, Andrea, & Rimm, E. B. (1995). A gender-specific measure of binge drinking among college students. *American Journal of Public Health, 85*(7), 982.

Wenzlaff, Richard M., & Wegner, Daniel M. (2000). Thought suppression. *Annual Review of Psychology, 51*, 59-91.

Wiers, Reinout W., Rinck, Mike, Kordts, Robert, Houben, Katrijn, & Strack, Fritz. (2010). Retraining automatic action-tendencies to approach alcohol in hazardous drinkers. *Addiction, 105*(2), 279-287. doi: 10.1111/j.1360-0443.2009.02775.x

Wingenfeld, K., Bullig, R., Mensebach, C., Hartje, W., Driessen, M., & Beblo, T. (2006). Attention bias towards personally relevant stimuli: The individual emotional Stroop task. *Psychological Reports, 99*(3), 781.

Witte, K. L., Freund, J. S., & Csiki, I. (2002). Case-mixing effects on anagram solution. *The Journal of General Psychology, 129*(2), 117-126. doi: 10.1080/00221300209603132

Xu, Xiaomeng, Demos, Kathryn E., Leahey, Tricia M., Hart, Chantelle N., Trautvetter, Jennifer, Coward, Pamela, . . . Wing, Rena R. (2014). Failure to replicate depletion of self-control. *PLoS One, 9*(10), 1-5. doi: 10.1371/journal.pone.0109950